PONDS AND FISH CULTURE

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For Pleasure or Profit

by

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To three men to whom so much is due for successful fish culture, particularly in Britain: C. H. Roberts, chief of the former Fisheries Research Station in Hampshire; D. F. Leney, one of the great and most knowledgeable of fish culturists of to-day; and the late Alan Gardiner, biologist, the colleague who introduced me into the absorbing interests and mysteries of the culture of fish in ponds

ACKNOWLEDGEMENTS

The photographs of garden pools, goldfish ponds and water gardens show how one can beautify home surroundings. These pools and ponds, and many of the rocks, are built of cement and concrete following instructions given in the several helpful pamphlets issued by the Cement & Concrete Association of 52 Grosvenor Gardens, London S.W.1. The Association had the photographs specially taken and has kindly supplied them for publication here.

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ILLUSTRATIONS

MAXIMS FOR FISH FARMS

The following digest of hints and warnings in connection with the routine of a fish farm might serve a useful purpose if the management had them typed out and placed on a board hung in the hatchery or at the entrance to office or store as a continual reminder to assistants.

*

Do not overcrowd. The less fish in trough or pond the quicker and bigger they will grow.

Do not overfeed. It will unbalance the fish and render them easier victims of ailment and disease. Uneaten food will foul the water.

Do not handle the fish more than necessary. Do not frighten them, they may injure themselves and the slightest wound may be a lodgement for fungus.

Do not hurry or scamp work. Carry on quietly, slowly and methodically—especially in the artificial spawning operations.

Test the water frequently for temperature. Also for levels in troughs and ponds.

Absolute cleanliness is essential in hatchery or elsewhere; and also with all tools and utensils.

Do not allow vegetation in ponds to become rampant.

Keep screens, inlets, outlets and grids cleaned of weeds and debris.

Sort the fish frequently and keep the sizes separate in different ponds, thus preventing too much cannibalism.

Do not panic at losses. A loss of 50 per cent of ova, alevins and fry may be expected. Remember it is agreed that only one out of every thousand naturally spawned salmon fry grows to be a mature salmon.

When using wood which will be in contact with fish see that it is black-varnished.

Rules for the hatchery house—such as 'No smoking', 'Shut the door'—should be strictly obeyed. A door, carelessly left open, may admit unobserved rats, wrens and robins.

In the hatching season make at least one daily inspection of the troughs and pick out and take away for destruction, all dead eggs and debris. Fungus appears very quickly on dead eggs and spreads rapidly.

Watch intake and outlets of water daily for adjustments that may be necessary. Watch filter and distributing pool for silt. If much silt, filter needs cleaning.

Mend immediately, or make secure against birds entering, any broken window in the hatchery house.

CHAPTER I

AN INTRODUCTION TO AQUICULTURE

An acre of water is worth far more than an acre of average land. Aquiculturists all the world over can prove the truth of this statement. Aquiculture? What is it? We all know the agriculturist but only a few know of the aquiculturist —the water farmer. Look in the dictionaries. They bracket aquiculture with pisciculture—the culture of fish by artificial means.

The other day I asked a friend—a most knowledgeable man—what he knew of aquiculture. He replied without hesitation:

'Oh, a system of growing vegetables and other things in water with the aid of chemicals instead of normal growing in the good earth. It started in California some decades ago and is quite successful.'

That certainly is a correct answer so far as relating to a novel, though by no means the most important, branch of aquiculture.

Aquiculture is the cultivation of life, animal and vegetable, in all kinds and conditions of water and, so far as fresh water is concerned, in the creation of ponds and lakes and the improvement of streams and rivers.

In the last century such giants of fish culture as Buckland, Francis, Halford, Armitage, among others, declared and proved that an acre of water is worth far more than an acre of average land. Excepting in the many lush water-meadows where kine are fattened, the agriculturist endeavours—and in many cases quite rightly—to get rid of the surplus water on his farm. It is regarded as a waste product. In recent years the waste products—though not water—of many manufacturing concerns have become valuable assets in the profit and loss account of the factories. And so it may well be that the waste product of the land—water—can become a source of profit to the agriculturist. From the middle of the last century the fish farm was gradually assuming an importance in the world of profit-making akin to, and

in some instances surpassing, the value of the land farm. Several fish farms, managed by experienced and diligent aquiculturists, attracted attention by their flourishing condition. The inevitable happened. Inexperienced men plunged gaily into a new scheme for making a rich and easy living. Disaster followed and there were more wrecks than flourishing fish farms. The experienced men, the leaders and propagandists passed away with the years and, in the new century, scarce two-score paying aquiculture establishments survived in Great Britain. Then came the wars—ten war years and the unrest in between—and existing fish farms could be counted on one's fingers. As in most other pursuits, to be successful the aquiculturist must thoroughly understand the business. He cannot know too much about what he proposes to do or about what has been accomplished by others in the past. It is because of this fact that this book has been written; it is the result of many years' study and practical experience. It should help the would-be aquiculturist, because an endeavour has been made to explain the lay-out, the working and the snags, experienced by successful fish farms in this country so well as in the Americas, the European Continent and China.

PLEASURE AND PROFIT

It should be realized that there are two very distinct branches of fish culture. One is for profit and one is for pleasure. The fish farms may be devoted to trout—for food markets and for re-stocking purposes; to goldfish—for sale; to carp—for specialized food markets; to coarse fish for re-stocking or anglers' bait. In addition to the piscicultural side of aquiculture there is the cultivation of natural fish food and water plants for sale to aquariums and that vast army of amateurs who have garden ponds and keep goldfish and other aquatic animals as pets or hobbies. The pleasure side may include the stocking of a pond or lake to provide your table with food or yourself with sport; or perhaps, your interest lies in beautifying your garden with a pond or pool and seeing lively goldfish darting about among the water lilies or lotus plants. A fountain, a miniature waterfall, a water garden, may be in your mind's eye. The where, when and how of all these things are to be found in the various chapters of this book.

Pisciculture, the branch of aquiculture devoted solely to fish, is as old as civilization itself. That we have records from about 3000 B.C. is marvellous; yet there they are in China, the centre of that early civilization.

Fu Hi, the first of the Five Emperors, developed new fishing methods. He enriched the knowledge of pond culture. Carp was the principal fish at that time but, by building brackish-water ponds, grey mullet were cultivated and soon became established to vie with the carp. From 2357 to 2205 B.C. the Emperors Yao and Shun kept watchful eyes on the pond fisheries and appointed fishery inspectors and instructors. From that time there are no further definite records until 475 B.C., when Fau Lai wrote a classic on the cult of the carp, which to this day would scarcely need improvement. Goldfish originated with the Sung Dynasty (A.D. 960–1276) and speedily became ornamental pets throughout China. A famous book, *The Complete Book of Aquiculture*, was published in A.D. 1639 by Hsu Kwang Chi of the Ming Dynasty.

China to-day continues, as she has done for centuries, to be the leading nation of the world for pisciculture. Ova and fry of pond fish are exported to the East Indies, Thailand, the Malay States, Singapore, Formosa, Siberia and are also shipped throughout the vast territories of China itself. Through its centuries of history, fish culture became allied to the other great industries of China—silk and rice. These three—known in olden times as the 'Wealth of the Empire'—go hand in hand, helping each other to sustain that wealth, for when the ponds are drained once a year for the purpose of cleaning, the bottom mud—very rich in organic matter—is removed and used as fertilizer for the mulberry and fruit trees and for the rice fields and vegetable gardens. The food problem for the fish is easily solved through the utilization of rice and silkworm waste and the silkworm pupae which are left over after their cocoons have been spun into silk yarn.

ARTIFICIAL PROPAGATION

Pisciculture was known in Europe also in olden times. It was in the days of Ancient Rome that artificial propagation of fish became an art. Who discovered it, and how, is unknown. When the glories

of Rome faded so did the art of artificial fish culture and, strange to say, it was lost for several hundred years. The story of the luxurious Romans in the zenith of their fish-breeding epoch reads like an extravaganza. Most attention was paid to fish from the sea, especially mullet and bass, but freshwater carp were well to the fore. Ponds and lakes and huge aquaria were constructed and stocked with the choicest of carp, mullet and bass. Great consideration was given to breeding and fabulous prices were paid for selected fish. All sorts of cross-breeding was attempted and some succeeded. Lucullus was renowned as having the finest and best variety of fish, valued at the equivalent of several thousands of pounds. Men built palaces near their ponds in order that they and their friends might have banquets in the perfection of fresh-caught fish. Sergius Orata was the originator of artificial oyster-beds. Others followed his lead. The oysters came from Britain. Another noble Roman bored a tunnel through a mountain in order to get sea-water to his ponds. Both oysters and fish were highly flavoured by special artificial feeding. A species of bass, which fed where Roman sewers discharged into the Tiber, was the most greatly esteemed.

Pisciculture to-day is not an extravaganza but a strictly commercial proposition in all countries. So far as Europe is concerned, the art of artificial hatching of fish, so long lost, was rediscovered a century ago by a Scotsman, Shaw of Drumlaugrigg; by James Hogg, the Ettrick shepherd; by Remy, a French peasant of La Bresse in the Vosges and by Jacobi, a German savant. Shaw and Hogg—the one a wealthy salmon enthusiast, the other a humble student of fish-life—were interested in the controversy raging at that time as to whether a parr was the young of the salmon. Both experimented and saw their marked parr assume the scales of the smolt. In their experiments, to ensure properly impregnated ova, they squeezed milt from a male and thus discovered artificial spawning. Joseph Remy, a simple river fisherman, could not understand why there were so few fish in the rivers when, at spawning time, there were so many thousands of eggs. He made a nest on his own, filled it with ova and milted it. Much to his surprise he had a fine hatch. Later, when the facts became known, the Academy of Science successfully experimented on Remy's lines and created a sensation. The Government took the matter up and artificial hatching became, once again in Europe, a commercial

fact. Professor Jacobi had been studying trout life and made successful experiments similar to the others just mentioned. The German Government gave him a pension and Germany, in a few years, was established as a fish-breeding power in the world of pisciculture.

France was the first of the countries to open a proper breeding station. This was situated near the Swiss-German frontier at Huningue. At first only game fish, such as trout, were hatched. The particular Ministry which had this establishment in charge, distributed the eyed-ova and the young fish to selected rivers. Other countries followed France's lead with official hatcheries and in a few years commercial hatcheries were to be found in every country. Because of the growth of this new and important industry, Governments established fishery research stations to help breeders with the many problems that cropped up.

In this country, at that time, all fishery matters were in the hands of the Board of Trade and mostly appertained to the sea fisheries in which Britain was the leader among the countries of the world. Freshwater fisheries had only a tiny place in the Whitehall office. In this mid-Victorian period salmon and trout fishing was the privilege of the few who owned the waters and preserved their fish as they did their pheasants. It was a luxury sport and society flocked, at the proper seasons, to the North—for salmon fishing as for the grouse shooting, or to the South—to the Test, Itchen and Kennet, the noted trout streams. Then Buckland and his colleagues came into the picture and created a wider interest in both angling and fish culture. The interest increased, hatcheries flourished, angling associations were formed. Angling and ichthyological literature was plentiful. Gradually, however, the enthusiasm faded. This may have been due to several causes. The deaths, perhaps, of Buckland and his associates; the industrial boom in the country and the consequent pollution of rivers and streams; ignorance of the right cooking methods for coarse fish and its consequent unpopularity. Hatcheries dwindled and freshwater fisheries faded to a low ebb until, many years later, the Fisheries Department was formed and allied with the Ministry of Agriculture.

Matters were different on the Continent, particularly in the Germanic countries and in Italy. Steady progress was maintained and fish farming, by the beginning of the present century, had become

a major industry. Both Munich and Vienna established research institutes which soon led the world in pisciculture. Italy, in addition to Comachio with its huge output of eels, mullet and plaice, started a goldfish industry which, until the wars, grew to become the world's largest exporter of goldfish.

GROWTH OF PISCICULTURE

The most wonderful forward movement in freshwater fisheries happened toward the end of the last century in the United States. As interest dulled in England so it increased in America. Seth Green, America's first fish farmer of note, published a text-book on trout rearing. It was widely read and the interest it aroused produced a new industry. This was fostered, too, by an U.S. Admiral who, on returning home, brought with him goldfish from Japan and China, and thenceforth the goldfish industry became an important factor in American aquiculture.

The Federal Government established the Bureau of Fisheries and began breeding many different species of fish and distributing fry and eyed-ova all round the country free to anyone who applied. Various State governments became interested and established fishery departments. Some of these were attached to State universities, others had their own research stations. All the authorities had four aims: To introduce game fish into all possible waters; to propagate fish; to conserve and protect fish; to improve fishing streams and waters generally. The results in recent years have been amazing. Hundreds of millions of ova have been hatched; fry and ova distributed by means of specially-built and equipped lorries and railway carriages—free to all who have a home for the fish in their ponds and local waters. Improvement of streams has been carried out on a large scale. Small parks have been laid out on the banks of rivers and lakes for the benefit of local anglers. Farmers have been encouraged and assisted to establish fish ponds to serve a double purpose—supply their table with food and give anglers an opportunity of good fishing. The anglers pay for the privilege and the farmers thus secure an additional source of income.

This latter idea has been prevalent in England for some time, too, Most of the reservoirs and some private lakes supply fly-fishers with

sport on season tickets or day tickets, at a price. Angling Societies and Clubs lease sections of rivers and canals from local Fishery Boards.

Wisely, perhaps, the Government in this country, does not propagate fish for the public service. It leaves that to private enterprise and thus allows fish farmers the opportunity of increasing an industry which, while not new, is of small proportions at present. Trout culture has been the main objective in the past. But, due to various circumstances, there seems to be an increasing demand for home-produced goldfish, carp, tench and eels. The import of these fish annually was some thousands of tons. Denmark, Holland, Norway, Germany, Italy, Eire, have all exported their carp, tench, eels and goldfish to this country while British exports covered only a small quantity of salmon, trout, and eyed-ova.

Between the wars, when this country was flooded with goldfish from Italy, and other countries sent carp, tench, and eels, the market prices were so low that home production costs were not covered and fish farms either closed down or continued with trout only. Now the demand is much greater than the supply, particularly in goldfish, and prices rule high. Home-bred fish have much in their favour. They are acclimated and, therefore, better able to withstand in open ponds the weather of the British Isles; they have not been subjected to long and fatiguing travel which saps vitality and—well, a dozen other arguments. And the present seems to be the time of opportunity.

THE IMPORTANCE OF WATER

Water is increasing in importance and value. Some of it is owned or controlled by municipalities, by other authorities or private individuals. However, there is a great deal of water. One county in Scotland has a thousand lochs. There are other sections of Britain where there is water as yet unoccupied and a hunt round by the prospective fish farmer may result in finding an ideal location. Then, again, the example of the water-cress industry is worth consideration. Many successful cress growers have made cress beds which are maintained by means of artesian wells with a nearby stream to take the overflow. A bit of sloping waste ground may well be developed with an artesian well into a successful commercial fish farm or provide an

interesting and not unprofitable hobby for the amateur aquiculturist. Many details toward this end meant to be definitely helpful to all are to be found in the various chapters following, in this book.

Reproductive potentials of fish are great, for Nature has been particularly bountiful in the matter of fish ova. She has made generous allowances for the toll taken by predacious enemies, disease and unfavourable conditions. Freshwater fish compare well in spawning capacity with sea fish. The cod of twenty pounds weight may produce five million ova, but the carp, a much smaller fish, at five years of age and weighing only five pounds, will produce half a million. The game fish of the trout and salmon families have a recognized output of one thousand ova for each pound of weight after reaching a favourable age. Other averages of freshwater fish per pound weight are: roach, half a million; pike, ten thousand; perch, forty thousand; goldfish of medium size, from five hundred to one thousand.

In the last decade or so, much progress has been made in aquiculture and especially in pisciculture. Valuable results from those years of research are nowadays constantly forthcoming. Fish research needs divers scientists to enlighten this field on its basic problems. There are so many phases in fish culture—needing help from the chemists, physicists, physiologists, ecologists, pathologists, biochemists, embryologists, nutritionists, zoologists, and botanists. A long list it appears, but as fish culture grows and civilization advances and brings with it new problems and difficulties, the work of such scientists becomes not only desirable but necessary. Many of the scientists engaged on the various aspects of fish problems may have little practical knowledge but their theories and the results of their researches, each in their respective lines, can be co-ordinated for the aquiculturist to translate into practical procedure. The aim of this book is to try to express in simple terms the co-ordination of scientific research allied to many years of practical experience.

NATURAL AND ARTIFICIAL FEEDING

While water in quantity and quality has always been of first importance to the aquiculturist, food has been a close runner-up. Nowadays, food importance has grown to such an extent that it has become almost an equal factor with water in the successful maintenance of

fish farms. It is, of course, the world food situation that has created the problem of what to use as substitutes or supplements for natural food in the daily diet of fish. This difficulty is not so great with goldfish and carp, because these fish thrive well on cereals, vegetable matter and such like. Trout, however, do not take too kindly to substitutes unless they are confined to sea-fish and meat. These matters are discussed fully in Chapter XIII.

Even without the detailed results of a multitude of experiments in artificial feeding there are examples—all over the world—proving the tremendous importance of food in relation to the growth of fish. In Britain there is the quite recent case of a loch in Scotland where chemicals were used to create natural food. The loch has an extent of eighteen acres. It was stocked with one thousand fry per acre. From April to September, six hundred pounds of sodium nitrate and four hundred pounds of superphosphate were distributed, monthly, in the loch. In the following year this dosage was doubled. Two important facts were revealed: the fish fed during the winter and as two-year-olds had the size and weight of six-year-olds.

In China, Germany, Austria, Hungary, and Poland the average harvest of carp is two tons per acre. In most of these countries the growth is attributed to the sewerage waste waters of towns being allowed to flow into the lagoons or larger ponds of the carp farms. In one case pond-cultured fish weighing eighteen hundred pounds were placed in the waters. In the autumn fifteen thousand four hundred pounds were fished out and sold for nearly one thousand pounds.

In Tasmania there are the giant trout—become giants by living in virgin waters abounding in natural food. New Zealand and Australia have astonishing cases of yearling trout weighing three pounds; of rainbows of sixteen and a half pounds at three years of age, and so on.

THE BROWN TROUT OF BRITAIN

The brown trout of Britain were introduced into all these countries, and other parts of the world, and it is from this British stock that the big fish have come. There are brown trout hatcheries everywhere—in the Himalayas, in Java, in Ceylon, in South Africa and

other Dominions. In the Americas the British brown trout is in high favour, particularly the Lochleven. In all these countries there is governmental culture of fish and a tendency to assist in the establishment of fish farms. Australia is the latest to enter the field and has just begun culture of its best native fish, in addition to brown and rainbow trout. Fish culture, since the war, has been taking rapid steps upward. Britain should not lag behind.

Prominent ichthyologists in the United States are seeking a universal pond fish. One suggestion is that all countries should introduce from other countries warm-water so well as cold-water fish in an endeavour to find the universal freshwater favourite. They have begun by introducing mullet. This, undoubtedly, is a market favourite. In North Carolina, both *Mugil cephalus* and *Mugil capite* have been introduced to freshwater from the sea and brackish water of estuaries. In one season fry of three inches have grown into fish of nine inches, and the increase of weight has averaged two thousand pounds per acre. Opinion in Britain is against the import of foreign species for fish culture, although the rainbow trout has become established here. The mullet can be classed as a native fish for it can be caught along the shores of the British Isles. Its cultivation in freshwater, along American lines, is worthy of consideration by enterprising fish farmers here.

There are many people who do not know fish in all their infinite variety, and therefore, do not appreciate them. Plato—probably with a fish bone stuck painfully in his throat—wrote: 'Fish are made out of ignorant and senseless beings who had committed all sorts of sins and because of this they are not permitted to breathe pure air but were thrust down into the waters where they had to breathe in a deep and muddy medium—and hence arose the races of fishes and oysters which received the lowest habitation as a punishment for their extreme ignorance.'

But such ignorance may lead us to bliss. Fish is gradually coming into its own high place in the modern world. What is more beautiful than gleaming, golden fish, swimming in a lily pond; more invigorating than the lively fight with a fish at the end of an angler's line or more delectable than a well-cooked dish of freshwater fish on the table?

It may be noted that practically all modern appliances in freshwater

fish culture originate in America and that a majority of the publications in this field emanate from the United States Bureau of Fisheries and other U.S. and Canadian sources. Unquestionably, the hub of fish cultural research has moved from Germany and other Continental countries to America. This is not to be wondered at. While Britain is the pioneer in establishing the brown trout in the world at large, and is also supreme in sea fisheries, America, with tremendous leaps and bounds, has become the world's leader in freshwater fish production and research. The wild waters of the United States and Canada are gradually becoming controlled and populated with suitable fish.

The results of research in the United States and Canada are of the utmost value and can be accepted, without question, by British aquiculturists because they are not based on theory and laboratory experiments only but on practical experience over a period of time.

CHAPTER II

GARDEN PONDS AND LILY POOLS

The definition of a pond is a 'pool of standing water' and one of the definitions of a pool is an 'enclosed body of water'. But whether it be a pool, basin, lagoon or small lake the term pond really covers all of them.

In every garden, however small, there is some site, some corner, where a pond could be established to add beauty and interest.

The miniature garden pond needs little excavating or construction and yet can so easily be made into a beauty spot. One-half of a wooden barrel or hogshead sunk to just below ground level will form the container of such a pond. Do not use any barrel which has contained oil, tar or chemicals—one cannot clean them enough, even by burning out, to make them safe for fish. If half a barrel be difficult to procure then an old bath, cistern, copper or tub should be used. Metal, however, is toxic to fish and must be coated inside with bituminous paint. In the aquicultural world this is known as 'Black Varnish'. Even if a half-barrel or other wood receptacle be used, a coat of this paint on the outside will help to preserve the wood from the acids of the earth and also ensures water-tightness.

Having sunk the receptacle three or four inches below ground level, ram down the earth on the outside of it. Then group rocks, large and small, around the pool, some of the larger and some of the flat ones on the rim so as to slightly overhang. Put four inches of loam in the bottom of the receptacle with two inches of well-washed sharp sand on top of the loam. Such a pond will make a happy home for three or four goldfish but not more. One miniature water-lily and three marginal water-plants should not be exceeded. Plant Alpines in the crevices of the rockery stones and grow clumps of other colourful flowers as near the pond as possible. Details of the best plants for such ponds and methods of planting are given in Chapter XV.

Ponds, other than the miniature ones, must be classed with pools, lagoons and water-gardens.

THE GARDEN POOL

There is nothing more effective than a pond centring a water garden and this filled with luxuriant water plants in which the British Isles are so rich. There can be a little waterfall tinkling down in a cascade over rocks or perhaps a fountain splashing crystal drops; again, with a lagoon-shaped pond, maybe a rustic bridge across its middle, from which to contemplate the fish darting hither and thither and the water-lilies showing their stately coloured blooms on the reflecting surface. Even stepping-stones can be a pleasant feature in a pond.

If the pond be properly stocked there will be no mosquitoes or gnats—they and their ova are food for the aquatic life. There will not be enough frogs for a croaking concert. It may be years before the pond needs cleaning—the natural scavengers attend to that. In winter, a season when work in the garden is not too pleasant, there is little to do with your pond except to see that a couple of air-holes are open in the ice should the pond be frozen over. The maintenance of a garden pond is not troublesome. Once established it will, more or less, look after itself. In Spring and Autumn, if the plants grow too profusely, it may be necessary to thin them out. Any other work is no more than would be done in any other part of the garden.

SOILS AND DEPTHS

There are two types of pond—the natural and the artificial. A natural pond is a real blessing. If your soil is right, you can create a natural pond out of any fold or depression in the land. With such conditions you can also create a natural water garden.

Soil is an important factor. If the ground is sand or gravel you must give up the idea of a natural pond and make an artificial one. If the soil be clay you can go ahead and make a natural pond. In most cases some excavation will be necessary. The final depth should be from eighteen inches or two feet at one end sloping to a shallow of a few inches at the other. This for a small pond. A larger pond should have greater depth—from three to six feet with a gradual

slope to the shallow end. Full details for the construction of ponds of various types are given in Chapter XI.

FOUNTAINS

A fountain in a pond has many advantages and also some disadvantages. It is not necessary for the welfare of the pond and its inhabitants. But, if a small jet is used and plays only for short periods, it has its uses. It helps to oxygenate the pond water and makes good what the pond loses by constant evaporation. Again it adds beauty, both in sight and sound, to the scene. If the water surface of the pond is on a level with the surrounding ground the fountain may cause an overflow which is good for the water garden around the pond. With an embankment, however, numerous little channels would have to be cut and maintained for the overflow to pass through.

There are two slight disadvantages. First—in a hot summer the fountain would cool the water to the detriment of the fish, which do not thrive with sudden changes of water temperature. Secondly—in many cases, the fountain would be served by main or tap water and such water is sterile. It has been chlorinated or otherwise treated. The microscopic organisms have been killed and it is these organisms that are of great importance to a fish pond.

Water, other than tap water, to be used in a fountain must be filtered before entering the pipe. Otherwise there will be constant trouble with a choked jet.

Fountains, as well as waterfalls, can be worked by electricity, either direct from a power plug in your house or garage or from a car battery. With a charger in the garage there should be little difficulty with a battery. Jets, both single and multiple, can be purchased to fit the water pipe. The jet is either plugged in or screwed into the pipe. If you create a water-garden surrounding the pond a revolving jet or sprinkler on the fountain would be found useful. An hour or two a day should keep the water-garden in perfect condition.

WATERFALLS

Waterfalls can be very picturesque. If the pond is supplied by

1. Artificial home-made rocks

2. Rectangular goldfish pond

3. Goldfish pond with fountain

water from a stream or spring or other natural source a waterfall, depending on the contour of the land, is easily arranged. But, if it is impossible to construct the pond at a lower elevation than the source of water supply it will be necessary to resort to artificial means. This entails electrical energy. There are a few firms who manufacture pumps and $\frac{1}{4}$ and $\frac{1}{2}$ h.p. motors especially for the purpose of artificial waterfalls and fountains. They aim at a market of pond owners who had no natural water supply for their ponds, solving their problem by the re-use of the water in the pond, which simply circulates over the rocks into the pond and returns. The water is thus highly oxygenated and only suffers slightly from evaporation when the motor and waterfall is shut off. Advantages of this pump are many. It is simple, small, very quiet and economical to run. No working parts are below ground level. Cost of maintenance is negligible. One pump fitted with a $\frac{1}{4}$ h.p. motor has a suction lift of twenty-seven feet. Where electricity is not available it is mounted complete with a $\frac{1}{2}$ h.p. petrol engine. With foot valve and a deep well device this pump has given a suction lift up to one hundred and sixty-five feet.

With a $\frac{1}{4}$ h.p. motor, the pump with all piping and connections is quite moderately priced. The petrol engine is more costly.

Pipes, motor and pump are all out of sight and the waterfall or fountain can be switched on or off at will.

MAKING ARTIFICIAL ROCKS

A waterfall should have plenty of rocks over which it cascades. If rocks are unprocurable locally except with difficulty, one can have recourse to artificial ones. Here again cement plays its part. It is possible with the aid of cement and sand to convert all sorts of rubbish into attractive rocks. Here is how you go about it. The mould is a natural one—a hole in the ground. Dig an irregular hole equal in size and shape to the rock required. Sprinkle generously the bottom and sides of this hole with brick dust or any other dust that will give the surface of the rock colour and texture. If not enough dust material available sand can be used in lieu. Mix one part cement to four parts of sand, using only enough water to make a stiff paste. Dump some of this mixture in the hole. Then throw in any used

tin, pot, kettle—in fact any old rubbish of that kind. Cover each of them with cement paste, making sure that each is well covered. Then finish to the surface with the remainder of the cement paste and sprinkle sand on it. Leave the rock to harden. Depending on the weather this will take two or three days. To remove the rock, first dig around it and then lift or lever it out with the spade. The surface of it can be made rougher, if required, by scoring with a trowel immediately after lifting.

WATER GARDEN POOLS

Small, medium and large rocks will be required but, unless some are to be used for a decorative wall, slab shapes should be avoided.

A water garden, down the centre of which there are three or four small pools or basins, is an entrancing feature and is not difficult to create. If you have a running water supply it is simplified, but the water must be controlled. For purely decorative effect and not as fish pools, the pools need be only a few feet—say four to five feet wide by six to eight feet in length and about a foot deep. Each pool is excavated at a lower level to the one above it. Make sure that the rim of each pool is levelled. The bottom levels are unimportant. The sides should be sloped and concreted. Three inches of concrete should suffice. Around each pool or basin place rocks irregularly. In among these and in the pools will be planted the rock plants and the water plants. The miniature waterfalls from pool to pool add to the pleasing picture. If there be no running water supply the pump apparatus already described can be used for these pools.

RUSTIC BRIDGES

The long, narrow sheet of water may be termed the lagoon type of fish pond. It may be a natural owing to the layout of the ground, or a 'natural' made in a clay soil. With a lagoon say, fifteen feet wide and fifty feet in length, it is very desirable to have a rustic bridge across its middle. This provides shade for the fish and adds beauty to the scene. The most useful materials for the footway of the bridge are old railway sleepers. A majority are sound enough for this purpose and will last for years after being discarded from the permanent

way of the railway. Curved poles, with or without the bark, form the handrails of the bridge. Use irregular-shaped ones where possible. This adds to the rustic appearance, a fitting reward for the increased labour difficulties in construction.

In a smallish pond an island is not advisable. But, in a large pond or a small lake, an islet can be usefully employed. By selecting the proper plants it can be developed into a dazzling centre of colour.

STEPPING STONES

For the lagoon pond there is a variant which may be more in keeping with the particular layout than a bridge. This is stepping stones. It may be considered to belong more to the informal type yet can give an artistic touch to almost any garden scheme. It is not only the stepping stones across the water, the stones can begin where your garden path reaches the water garden. Through the marshy wet ground one can thus step without getting muddy. The stepping stones here can be made of cement blocks. The natural environment of stepping stones is a rocky shore. As a water garden is, in most cases, full of skilfully placed rocks and rockeries and the pond or lagoon, no doubt, has many surrounding rocks, stepping stones add enormously to the general effect. Use natural rock if possible, otherwise the stones must be made with concrete. Those in the garden should be well above the ground level; those in the water must be above high-water mark—that is when heavy rains or stormy winds may raise the ordinary water level. The value of stepping stones, other than their artistic aspect, is to enable one to enjoy the water garden, dry shod. The greatest care must be taken, therefore, in positioning the stones in the water. A rocking or loose stone may be a joke to some but to the majority it is dangerous and annoying. The stones should be big enough to stand on with both feet. They should be placed at an easy stride apart. A zig-zag course should be avoided as it creates a sort of weir. In a stream or in a lagoon with running water, placing them in a straight line makes it possible for fish, weeds or debris to pass easily between the stones.

If the stepping stones are to be of natural rock, select those with a flat surface slightly depressed, if possible, or roughened. A smooth surface or rounded face both tend to slipperiness which must be

avoided. Cement blocks are, of course, excellent though they do lack the picturesqueness of the natural irregular rock or boulder. It is best to cement stepping stones, of whatever kind, to the bed of the stream or lagoon. This may be tricky work, but can be accomplished by using, temporarily, a caisson or a diverting dam.

RAISED PONDS

Raised ponds—where little or no excavation is necessary, are favoured by some garden lovers. The simplest form of a raised or terrace pool is of concrete. Shuttering must be used for the walls. Another form is to cement the bottom and build the walls of brick. As these pools are usually very shallow, a wall of twelve to eighteen inches in height should suffice. Wash the completed walls inside—up to the proposed water level—with cement and coat them and the floor with waterproofing paint. If lilies or lotus are to be grown in these pools, two feet of soil should be excavated before you lay the floor—this will give ample space for the loam required for the roots of the plants. The walls are a protection against winter frosts which is not so essential with ground-level pools, as the latter have the protection of the surrounding ground. The walls are also a guard if children are around so they will be less likely to fall into the water. These walls also offer seating accommodation when feeding or watching the fish.

LILY POOLS

One of the most decorative features of a garden is a lily pool set in a green lawn. There are so many houses which have only a somewhat dull square or oblong of grass in the small front garden. These could be vastly improved by a pool or basin. Drive a peg in the centre of such a lawn; attach a cord, measuring say three feet, and with this mark out a complete circle. The diameter of the basin will be six feet, which is ample for the purpose. Excavate, sloping the sides to a base of four feet. Then, with hard core rammed in on sides and base, concreting can be done with a trowel. Two inches of concrete is enough. When set, waterproofing material should be painted on. When ready to plant the lily, cover a forkful of manure with loam of sufficient depth to take the roots of the lily.

'KEEPING' PONDS

A 'Keeping' Pond is where fish are kept for the table. It may be an ordinary natural pond or a concrete one. It is usually small and from eighteen inches to three feet deep. Running water is not necessary. Fish, trout mostly, are bought from fish farms and kept in such a pond, being netted out from day to day as required fresh for the table:

For a great number of years these 'keeping' ponds or basins have been a feature of the continental hotels and restaurants, particularly in the country areas. Visitors would be asked to select the fish they desired for dinner and the obliging fish-keeper, with an eye on a tip, of course, would net out the fish and hurry off with it to the kitchens.

The object of these 'keeping' ponds is to ensure absolutely fresh fish—trout, carp, what you will—for the table. The fish should be fed daily. Care must be taken not to overcrowd the pond; remember —one inch of fish (less tail) to one gallon of water. Do not re-stock the basin until the last of the previous batch has been taken out. The 'keeping' pond is not a growing nor a fattening pond. To fatten up yearlings or two-year-olds, that have been purchased from a farm, a proper pond is necessary. Only when they have reached the desired size can they be netted out and placed in the 'keeping' pond for, more or less, immediate use.

THE FORMAL GARDEN POND

There are some garden lovers, no doubt, who do not care for the lush, wild-growing water garden. However, they may still desire a small pool in trim surroundings. Such may be termed a formal garden pool.

Having selected the site first measure off in the very centre the ground for the pool. It may be anything from three feet to six feet in diameter. Excavate the soil to a depth of two feet. The sides should slope slightly outwards. If the soil is clay the bottom should be puddled and small stones may be rammed in on the sides. Otherwise use concrete. Whether the bottom be clay or concreted there must always be, in this size pool, a sump, by which the pool can be emptied

when desirable. The sump should be at the one end or in a corner. Dig down a foot or two lower than the bottom level of the pool—the width of a spade will suffice—and fill this cavity with gravel, stones or cinders. Insert a short length of pipe—2, 3, or 4 inch, the larger the quicker the emptying. Fit into the top of the pipe a plug which can be a bung or shaped piece of wood wrapped in hessian or rag. It should have a short wire or rope attached which will facilitate pulling it out of the pipe when required. See that the plug is fitted into the pipe before cementing around it.

The concrete construction of the pool proper finished, a ledge from nine to twelve inches high can be made with concrete by using shuttering. This on a small job is not difficult. The bottom and sides of the pool will need waterproofing, but the ledge needs only a washing of cement. An additional effect can be achieved by using tiles of one or various colours.

There could be a flower urn at each corner, pressed firmly into the top of the ledge while the concrete is still wet. These urns, in white stone, can be purchased, but less expensive and quite efficient substitutes can be made from two nail kegs, sawn in halves and painted. Put in a shovelful of gravel, small stones or cinders, then a shovelful of manure and fill up with loam. Ferns, small flowering shrubs or flowers can be planted in the urns or kegs. Dwarf flowers are suitable for the border along the outside of the ledge.

A brick surround to the formal pool comes next. The turf around it should be taken up to a uniform depth of six to seven inches. For a three-foot diameter pool measure off a square of ten feet; for six-foot diameter it should be twenty feet square. On the excavated ground place sand at a uniform depth of four inches. On this lay bricks. Red bricks look the best and continue to improve in appearance with the weathering of the years. As each brick is laid it should be given a smear of cement paste on the side and end which join its fellow. The bricks must not be all laid in one direction. Lay the first row lengthways, North to South say, then the next row lengthways from East to West. It may be necessary here and there to fill in with a half brick. In order to get the halves as even as possible put a straight-edged piece of wood or ruler across the smooth side of the brick and score a line as heavily as you can with a knife or trowel or other tool. Then, holding one end of the brick firmly give

it a sharp tap with the trowel toward the further end and it should result in two more or less clean-ended halves.

The bricked square completes the formal garden-pool. Its very simplicity is beautiful. It has dignity. Its classical lines are very attractive.

THE SUNKEN GARDEN

A delightful feature in many picturesque grounds is the sunken garden. In gardens of any size at all there is quite often some point of depression suitable for the creation of such a garden. Doubtless it will be of an irregular shape, so excavation will be necessary to make it the particular shape desired: rectangular, square or oval.

Begin work in the centre on the pond which need not be large and may be used for a few goldfish or for water-lilies. Immediately around the pond there should be a path of crazy paving stones or brick. In making the pond do not forget to paint the cement with waterproofing and to arrange the water inlet pipe and the outlet sump before laying the concrete.

A TIER OF STEPS

All or much of the excavated earth can be used to emphasize the banks surrounding the sunken garden, the entrance to which will be by steps. These steps are easily constructed with concrete and can be either straight-edged or curved. First dig out the soil, shaping a sloping terrace or tier of three, four or more steps, say, when finished to be one foot broad, three feet long and eight inches deep. Make a framework or formwork as it is called, of one-inch boards according to these measurements or whatever measurement desired. This formwork must be whitewashed or oiled on the insides to prevent the moist concrete from adhering to it. This formwork will be used in turn for each step. Begin at the top. Place the formwork in position and then ram in five inches of small stones, shingle or very coarse gravel in the bottom—also a fair quantity rammed in the back of the cavity. Mix enough concrete to cover and tamp it down. The ratio is one bucket of cement to two of sand to three of shingle or aggregate not coarser than half inch, and half a bucket of water.

Sprinkle water on the hard core on bottom and back before applying concrete. Do not remove the formwork until the following day unless there is urgent need for haste in finishing the job.

After removing the formwork go over the sides and front of the step with a few trowels of concrete to fill in any crevices. Then smooth down the whole step with a cement wash of one part cement and one part sand. Fix the formwork for the next step and carry on as before.

A damp sack over each step after concreting or washing is a necessary protection from sun or heavy rain.

To make curved steps, dig the tiers in the line of the curve, drive in a stake where the centre of the outward curve will come and a solid peg at each of the ends. It helps also to drive stakes midway between the pegs and central stake. For curved steps measurement must be calculated on a different basis from those applicable to straight steps. Three feet in length is on the small side, so length should not be less than four feet at the back with a depth of nine inches. The extreme width will be one foot ten inches.

To make the formwork for the curved step: take a strip of thin plywood or tin, five feet six inches in length and nine inches wide. Punch a hole in each end to take a short piece of string or wire. Circle the strip around the stakes and tie the ends securely to the pegs. Then proceed by ramming five inches of hardcore and tamping in four inches of concrete—one, two, three, mixture as before stated. After removing formwork use concrete with a trowel to fill up any crevices and smooth over the step with a cement wash as described for straight steps. Do not forget that whitewash or oil must be used on the inside of the strip before fixing.

In a small sunken garden it is well to have a flower border along the base of the bank. The remainder of the ground surrounding the pool could be turf or gravel.

In a larger sunken garden the border around the bank might be of flowering shrubs with two or more flower beds in the surround of the pond.

Even with a small pond a fountain gives a pleasing finish.

For those who have a garden pond and wish to propagate their goldfish or other fish, an aquarium will be found to be of considerable value. The fish spawn mostly on the water-plants in the pond

or on branches which are cut and laid in the water at spawning seasons. The parents, as well as other denizens of the pond, feast on this ova. Some of it escapes observation, of course, and hatches out. The fry, however, are again in danger of being eaten by cannibal parents or other hungry inhabitants of the pond. With all these hazards there may be only an increase of a few fish that season. Hence the aquarium. After spawning has taken place, the branches or the leaves of the growing plants, impregnated with ova, can be removed to the aquarium and there the hatch can take place in peace and safety.

One's usual ideas on aquariums are the glass globes or the rectangular glass structures seen in pet shops and natural history museums. To the experienced aquarist the glass globes are condemned cells for goldfish, and in any case are useless for the purpose of hatching.

CHAPTER III

PONDS FOR THE FISH FARM

The aquiculturist who intends to establish a fish farm, after having acquired the land and water, will begin with the construction of ponds. The layout, size and construction depend on whether the farm is for (1) trout; (2) goldfish; (3) coarse fish.

If for goldfish the acreage can be small and the ponds built of concrete. For coarse fish old clay, gravel and chalk pits—in fact, any depression which holds water—suffices and saves the cost of excavating.

For a trout farm greater acreage is indicated and above all, it is necessary for all practical purposes, to have running water. There are trout farms that possess cement ponds, but they were built in the days of cheap cement and sand and bricks. Such ponds are not recommended. It is generally agreed, both in this country and abroad, that the natural pond, or as near natural as possible, is the better for the propagation of trout. Now for the fish farmer's first step—the 'layout'. The necessary buildings should, for many reasons, especially convenience, be near the centre, with the several series of ponds surrounding it on all sides. The series consists of:

(1) Spawning ponds (fry),
(2) Rearing ponds (yearling),
(3) Rearing ponds (two-year-old),
(4) Growing ponds (three-year-olds and upwards).

The spawning ponds, as such, would be used on a carp and on a goldfish farm, but on a trout farm they would be used for the fry.

A trout farm differs to a very great extent from a carp, goldfish or coarse fish farm. It would, therefore, be better to discuss first the requirements of a trout farm.

The trout (*salmo fario*) has a wide range of tolerance for variations

in oxygen so well as aquatic conditions such as acidity or alkalinity or hardness or softness of the water. But temperature is of much importance. Trout prefer cold water, yet they do grow and thrive in water at temperatures of sixty-five degrees and seventy degrees Fahrenheit. But for spawning purposes the water must be cold—the colder the better down to forty degrees, the definite minimum being thirty-eight degrees.

The trout farmer, therefore, may lay out his farm without much worry over the particular source of the water supply—so long as this water is clean and well aerated it matters not if it comes from a spring, a brook or a river. Springs are, however, the best of all waters. The spring or springs should have a fall of at least two or three feet, although five to ten feet is of advantage. If the supply of water is large, however, the bigger fall is not so necessary. A succession of ponds should be sited below the springs, the water from the first tier flowing into those in the second tier and so on. The reasons for this plan are several. Water and space are economized, the changing of fish from one pond to another is simplified, as is also the cleaning, manuring or any other necessary work on any individual pond.

In siting the ponds, avoid, if possible, positions where much surface drainage water will run into them. If this siting on this particular count is not possible, then a ditch must be dug to take such surface water.

VARIED DEPTHS

It has been found from experience that the shape of a pond is immaterial. Natural ponds are, of course, of all shapes and sizes. In very few cases is it necessary to re-shape or deepen these. The convenient shape and sizes—that is the handiest and easiest to work—are rectangular, twenty feet by seven feet; thirty feet by ten feet and fifty feet by fifteen feet. Larger than this is detrimental to the fish farmer in that the fish do not feed so well in large ponds and they cannot so easily be taken care of.

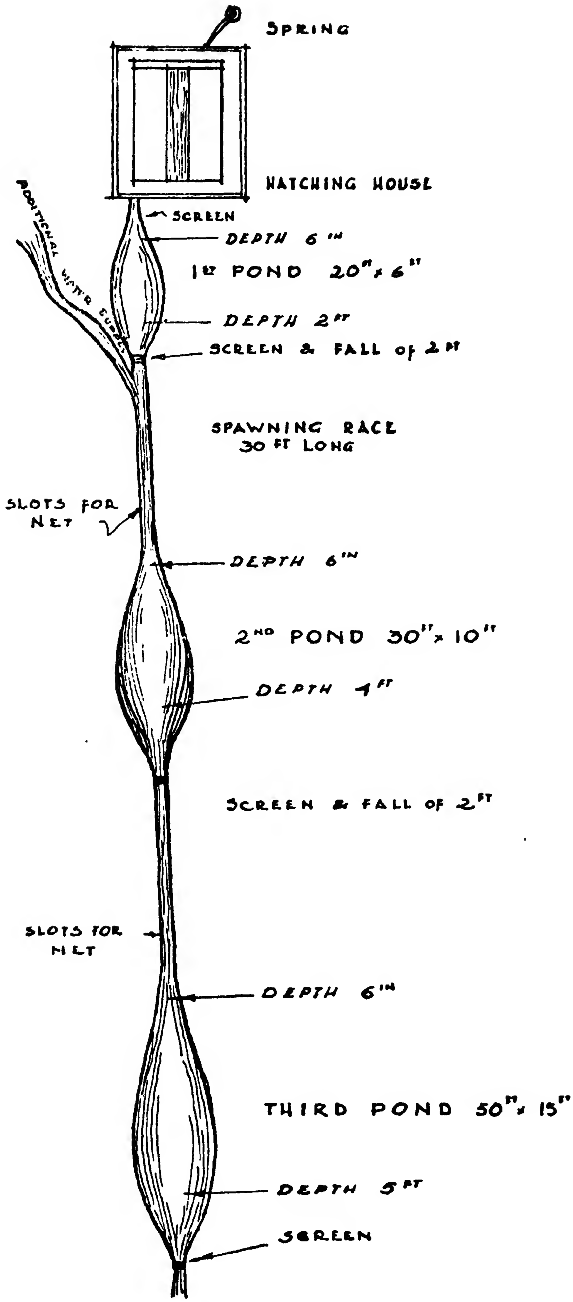
One can site the ponds in rows of from two to six, each series having a row. Leave six to eight feet of path between each pond; this is necessary as working room and must be wide enough to take

the handcart or any vehicle which you may wish to use around the ponds. There is no definite rule as to depth of the ponds on the fish farm and it may be anything from three to ten feet, depending upon the nature of the surroundings, the water supply and the temperature of the locality. On the Continent and in certain districts in the U.S.A. and Canada, where winters are more severe than in Britain, they have ponds with depths of thirty and forty feet. These special deep ponds are for winter use and during the periods they are in use the other ponds are emptied, cleaned and made ready for spring.

The long, narrow and deeper pond has been found to be better than the broad and shallow one. In the latter the temperatures increase more rapidly.

The aquiculturist must compare his work, planning, and layout with those of the agriculturist. While one has fish for his livestock, the other has cattle, sheep, pigs, and poultry. The land farmer arranges his enclosures, shelters, stabling, not alone for the comfort and betterment of his stock but also for the easement of labour in feeding and attending to them. The water farmer should follow these steps of wisdom gained by centuries of experience.

The trout farmer's ponds are for growing the fish. Therefore, the depth of the different ponds may be varied according to the age of the fish. Three feet for fry and yearlings; four feet for two-year-olds and five feet for older fish. These would be the maximum depths of a part only of each pond because there should also be shallows up to nine inches. Trout are fond of shallows, where they can bask. Both aquatic life and emergent weeds are found in the shallows and it is here also where land insects are usually plentiful as dainty morsels for trout. Young fish have greater security in the shallows from cannibals and some enemies. The bottom of the pond should be an easy gradient from deep to shallow. It does not matter of what the bottom may consist—mud, clay or cement. If the soil is porous, that is sand, gravel or chalk, then cementing may be necessary unless sufficient clay can be procured nearby. If clay has to be purchased and transported it may be cheaper and quicker to use cement. In some cases there may be a large water supply and a slightly porous soil could then be used provided there are no holes large enough for fish to escape and that the proper level of the water in the pond can be kept. Moss and other bottom weeds are undesirable and should



Raceways for Fry

be cleaned out as they appear. They are a nuisance in that they hide scraps of decomposing food, dead fish and detritus generally, thereby fouling the water. The amount of natural food they might supply to trout is negligible.

Ponds must be drained from time to time for cleaning perhaps, or repairs, or for changing fish from one pond to another. If the ponds are situated on sloping ground this is not difficult, but if on level ground it is sometimes a problem. The outlet is, of course, in the lowest part of the pond. A sump is scarcely a quick enough means of drainage on a trout farm. A short length of drain pipe inserted into the side of the pond at the point of its greatest depth could empty into a ditch running alongside. This pipe must have a fitted cap or cover on the pond end. As this is removed a fine wire screen must take its place—of course, also fitted—as the slightest irregularity or opening will be taken advantage of by the fish to escape.

RACEWAYS FOR FRY

On a trout farm the fry ponds will not be in the broad-sited series but will lead from the hatchery in a single line joined by long raceways. Should a very large number of trout be raised, further lines of ponds and raceways may be run parallel with one another. The water comes from the hatchery. Using the same water in each pond means economy in water, space, labour, and expense. There are three ponds in the line, all pear shaped. No. 1 is twenty feet in length, begins with a depth of six inches and ends with a depth of two feet. Through a screen the water flows into the first raceway. There is a fall of two feet here. This fall aerates the water and makes it as good as fresh from the spring. This first raceway is thirty feet long, four feet wide and six inches deep; the sides are boarded with inch and a half planks; coarse gravel composes the bottom, and runs into pond No. 2, the depth of which increases from six inches to four feet. At the end leading into the second raceway is a screen and another fall of two feet. This raceway is forty feet long and leads into pond No. 3. This pond is fifty feet in length and at its centre fifteen feet wide. The depth gradient is from six inches to five feet. All the gradients must be gently leading upwards to the raceways.

The supply pipe from pond to raceway can be extended and the

water allowed to fall on an apron to prevent the possibility of the fish jumping to the pond above. Trout will run upstream and take advantage of any small passage, but they do not go downstream readily. Trout enjoy the raceways. They like the swift-running water to free themselves from the parasites which sometimes trouble them or to go there if they are not feeling too well. To them a raceway is quite a health resort.

SHADE IS NECESSARY

For nursery and rearing ponds shade is necessary. Young fish like the early sun, but the midday glare of midsummer does them no good. Unless the water is shaded or partially shaded the temperature is raised. Trout grow most rapidly with a water temperature of fifty-five to sixty degrees. At a higher temperature their vitality is lowered and they are more liable to disease. One should not rely on trees for shade. Trees are a mistake on fish farms—at any rate when near the ponds. Wattle hurdles make good wind breaks but are hardly high enough to give the requisite shade at the right time of day. A collection of portable shade makers could be arranged by constructing various lengths of screens with hessian cloth tacked to poles. Old sacks, ripped open, can also come into use. Permanent holes should be made for the posts at the different ponds so that the screens can be placed and removed with ease. There must be no ragged or loose ends on these screens for the wind to blow about and frighten the fish.

Predatory birds sometimes become a nuisance on a fish farm and it is necessary to use wire netting over the ponds. If used, these wire screens will also provide the requisite shade by throwing on them, when they are in position, a few handfuls of weeds—water and land—long grass tufts, nettles or such. These wire screens can be used only in the nursery ponds attached to the raceways. Make light wooden frames, two feet longer than the width of the pond, and tack on the wire netting. A four-feet width of wire can be better handled than larger sizes.

CLEANING OF PONDS

Ponds need cleaning occasionally, but excessive cleanliness in the

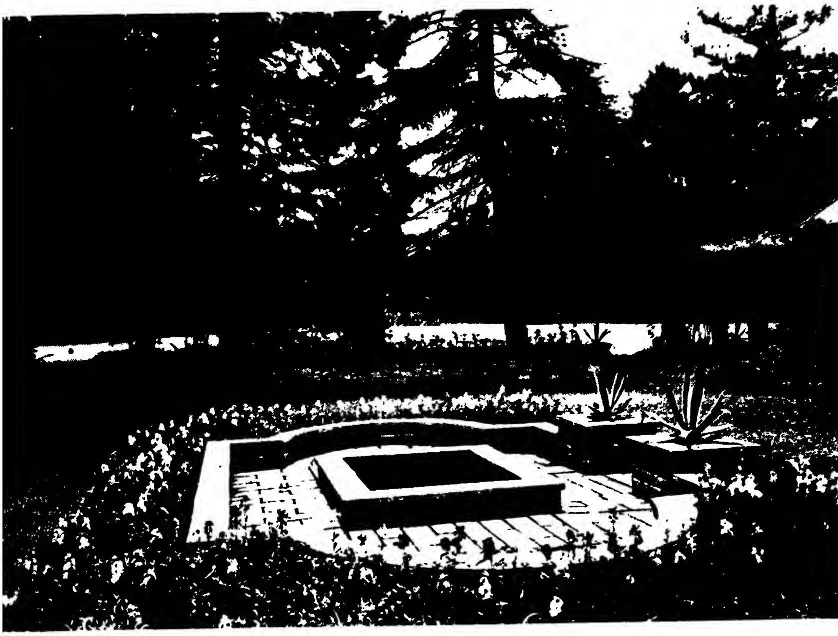
nursery or fry ponds is unnecessary. The raceways and ponds attached do a certain amount of self-purification. Then again, where the excrement accumulates on the bottom it soon supports a growth of small organisms which very quickly disintegrates it and the organic compounds are reduced to non-toxic substances. The insect larvae and algae produced are food for the fry. But in the larger ponds which contain the older and bigger fish, cleaning at intervals is advisable. The best plan is to remove the fish to another pond and then do a thorough cleaning job. Fresh water should flow through the pond for two or three days before fish are again placed in it. A bottom becomes filthy because of decomposing food and excreta which get covered over by silt and mud and plentifully overgrown with algae which helps to keep the filth packed and undisturbed. The over-lying water is not affected so long as the bottom remains undisturbed. Should it be, there will at once issue noxious gases toxic to fish. Under no circumstances attempt to clean the pond by using a broom or shovel while the fish remain. The algae will be removed in cleaning but will soon grow again. Algae must be encouraged, for fish feed on the minute organisms which find harbourage there. Algae, with associated organisms, are also most efficient in keeping the pond in a healthy condition. Algae aerate the water and keep it free from undesirable substances. However, it is absolutely necessary to keep algae, at all times, under control.

In heavy ground some fish farms use raised ponds. For trout they are not so good as ground-level ponds. Certainly the raised pond, in heavy soil, saves expense and labour in excavating.

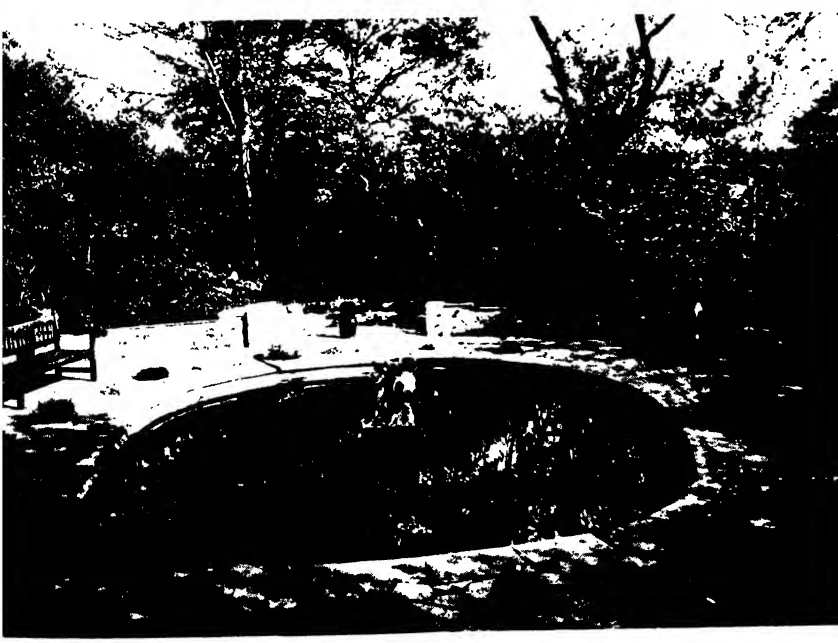
For this type of pond running from six inches to a depth of four feet excavating would only be necessary for part of the intended depth if on level ground. The excavated material can be used for the embankment. From the viewpoint of cost such ponds are desirable yet they must be expertly constructed. Otherwise there may be trouble from seepage or voles. Raised ponds of concrete are easy in construction but are used more on goldfish farms.

CIRCULAR PONDS

Circular ponds would appear to be more appropriate in parks and gardens than on fish farms. Yet some years ago Canadian and United

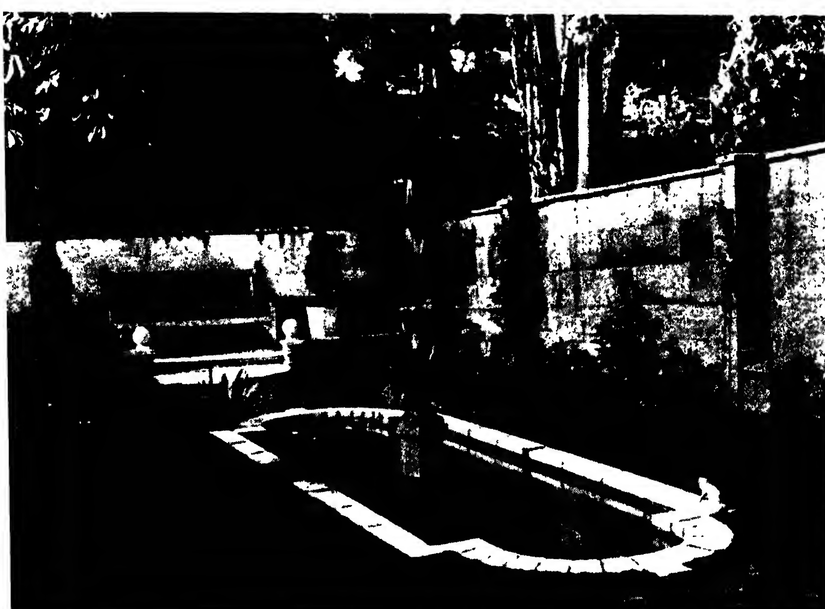


4. Ornamental raised pond for goldfish



5. Secluded pond with pleasant surrounds

6. Ornamental lily pond for goldfish



7. A corner pond with fountain

States fish hatcheries began to make many of their ponds of a circular shape. These hatcheries annually handle millions of eggs and require a great many ponds, particularly for fry. Arguments in favour of circular ponds are that they can be more easily drained and cleaned as they slope inwards to the centre; that in the severe winters frosts do not damage them so much as rectangular and square ponds and that it is easier to feed and attend to the fish and also simpler to protect them from predatory birds.

Here are some details of the construction of forty-eight circular ponds arranged in four tiers of twelve at a Canadian hatchery: The ground was first graded into a gentle slope. It was of somewhat gravelly and porous formation. Each pond is twenty-five feet in diameter and two feet deep in the centre. After the ponds were excavated a concrete slab was built in the centre of each to support the overflow and screen arrangements. The balance of the pond bottom was first covered with two inches of sand; on this was placed a tough quality of building paper—which is made of fibres and asphalt between two cemented layers. Clay filling was then puddled four inches thick over the paper. Sand was incorporated to form a binder. The main water supply pipe runs through the middle of the pond area with branch supply pipes to each pond. The main drain is immediately below the supply pipe, running the whole length of the system and connected with branch drains to each pond.

Some of these hatcheries also have ponds for rearing brown, rainbow and brook trout. Such ponds are one hundred feet long by five to six feet wide, with varying depths to five feet.

GOLDFISH AND CARP FARMS

Goldfish and carp farms may be bracketed. These fish belong to the same family and their requirements are, in most instances, similar. While some goldfish breeders claim that natural ponds are the best, many successful farms are composed of concrete ponds. The claim here is that with such ponds there is more and easier control and less labour.

The usual size for goldfish and carp ponds is forty feet by thirty feet, but they are more shallow than trout ponds. Two feet to two-and-a-half feet in depth are usual with three feet

for three-year-old ponds. The ponds should be in series and tiers as follows:

(1) Spawning ponds
(2) Rearing ponds
(3) Growing ponds
(4) Stock ponds

The number of ponds depends upon the extent of intended breeding. The capacity, per acre, of the different ponds is: Forty thousand fry; two thousand yearlings; eight hundred two-year-olds and three hundred three-year-olds. With artificial feeding these numbers can be greatly increased.

The proportionate area of ponds necessary for systematic culture is:

Spawning ponds	5 per cent.
Rearing ponds (yearling)	15 per cent.
Rearing ponds (two-year-olds) ..	20 per cent.
Growing ponds (three-year-olds) ..	60 per cent.

SUN AND WARMTH REQUIRED

The spawning ponds can be much smaller than the others and more shallow. When they are in use as spawning ponds the water, both for goldfish and carp, should be warmer than in the ordinary pond. The temperature should be from sixty-five to seventy-five degrees F. The sun and air will quickly warm a shallow pond. The temperature in a small, shallow pond can also be heightened by artificial means much more easily than in a large pond. For instance, hot water can be introduced.

The first of the rearing ponds should also be shallow and warm. Whichever sized pond is adopted, forty feet by thirty feet or fifty feet by twenty feet, some ten thousand fry can be released in it a few days after their yolk sac has been consumed. In a month or two, inspection of the fry will show difference in sizes. The fish should then be thinned out and the larger ones transferred to another rearing pond. On reaching the yearling stage they are again transferred to yearling rearing ponds.

The growing pond is for fish which have reached a two-year-old status.

No rule can be laid down as to the number of ponds required. Only the fish farmer himself can settle this question, which, of course, depends on the extent of plans made or outlined.

While the series of ponds described are necessary for the fish farmer who intends breeding carp, a lesser number may suffice for goldfish, as here marketing begins when the fish have reached a length of three inches. On some farms it may be that the fish which eventually reach and inhabit the growing ponds are only those selected as stock fish for breeding purposes. On the other hand carp would be utilizing all the ponds for at least two years before reaching table size.

In both carp and goldfish farms running water is not a necessity. The use of the same water, by piping it from pond to pond lying in series, is economical and labour-saving. But once the ponds have been filled the water should be shut off and only allowed to flow again to make up the small loss by evaporation. The water level of each pond must be kept as near constant as possible.

For these ponds water from a stream is better than that from a spring.

RAISED PONDS FOR GOLDFISH

Raised ponds are much used by goldfish farms. This saves much excavating. Sited on a slope few would need any excavating at all. The embankments can contain rocks, stone as well as earth—but no odd bits of timber or any rubbish must be allowed. The bottom of the pond must be clay, puddled, unless the natural ground stands up to the water, which it will do in marshy or peaty soil. A layer of sand on top of the clay or other soil will keep the mud from rising. On sloping ground the embankment will follow the slope. Make it at least six inches above the water surface when the pond is filled. Cut sods, and turf the whole embankment as the final touch.

The use of wood for the sides of a raised pond has also been successful. Slabs of elm, one and a half inches thick, of odd widths, planed straight on the edges, are screwed or nailed on to top and bottom rails of three by four inches. This frame is fixed on posts, six feet apart. The posts, imbedded in cement, are stayed from behind. To cement-in the posts, first excavate square holes six inches deep

and four inches larger all round than the size of the posts. Fill in with concrete consisting of one part cement, two and a half parts of sand and four parts coarse aggregate to level of the top. Tamp it in as the concrete is placed around the post. A bank of earth, including any available hardcore, is built up against the frame from behind. Some ponds, constructed in this way, have lasted for twenty-five years without need of repair.

Raised ponds with wood or concrete embankments are mostly to be found on goldfish farms sited on level ground. The series of tiers must have a drop from the shallow ponds in the first tier to those in the second tier and so on to the deeper ponds on the last tier. A drop of twelve inches on each tier is advisable but, if difficult to arange, a few inches will suffice; it is only required for the water flow when filling and emptying ponds.

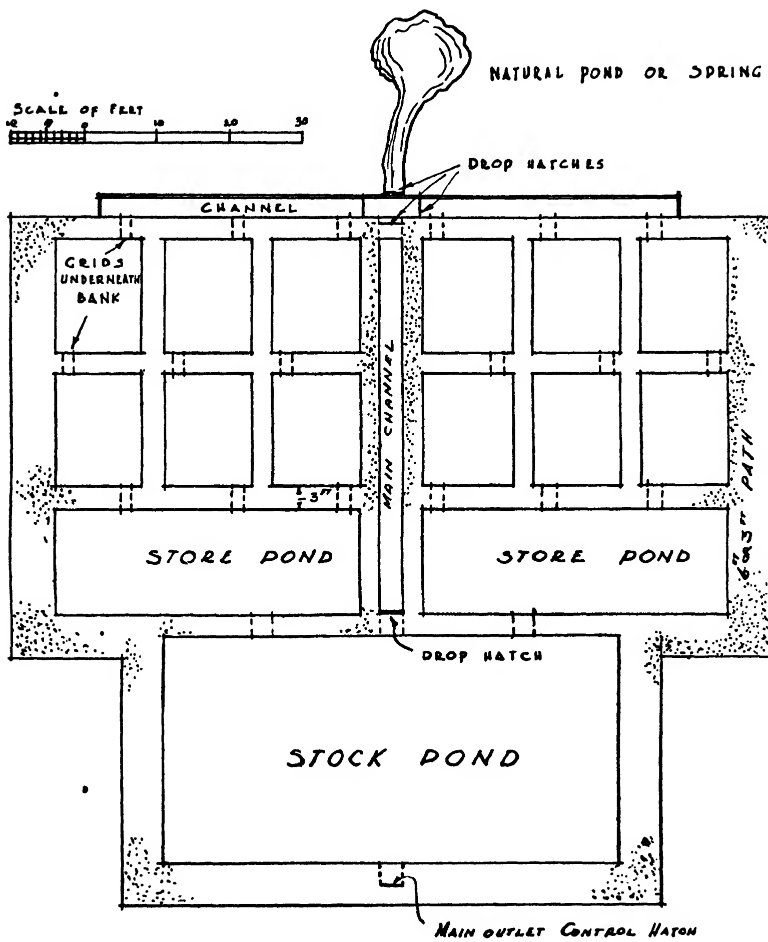
Making raised ponds in concrete means that shuttering must be used. It is important to make a good job of the construction of this shuttering formwork. If properly and carefully made it can be put together or taken apart quickly and easily. Plywood may be difficult to procure, but use can be made of a flexible asbestos wallboard, which is weatherproof. It can be nailed, sawn and drilled as if it were wood, and, with due care, will not split or fracture as the older type of asbestos was liable to do. This new board, $\frac{3}{16}$ inches thick, comes in eight-foot lengths with a width of two feet six inches, sometimes more. Using this material for the shuttering one can, both quickly and easily, construct goldfish ponds of sixteen feet by eight feet. The walls would be thirty inches. With two feet as the depth of water this would give six inches of wall above the water level, which is advisable.

MAKING THE SHUTTERING

To make the shuttering take two lengths of the board and fasten them together, leaving a six-inch cavity between them. The boards should be oiled or white-washed on the inner side to prevent the concrete adhering to them. The fastening together at both ends can be done by bolts and nuts with washers, or by hinged clasps, or by wood pieces drilled for thumb screws.

The first work on these raised concrete ponds is to lay a concrete

floor of six inches. The mixture for floor and walls will be the one, two, three.' Reinforcement in the walls can be made by any pieces of metal rod, wire netting or expanded metal. When the space for the floor is measured one foot extra must be allowed in the total length and also the breadth.



The floor being finished, the shuttering is then laid on it and, for safety's sake, can be firmly braced. The concrete is then shovelled in. Let the concrete set before removing the shuttering for use on the next part of the wall. After each operation the shuttering must be washed down and, if necessary, re-whitewashed or oiled.

POINTS IN CONCRETING

Particular care must be taken in two instances. First see that a good bond is secured between the bottom of the wall and the floor; secondly, see that the top edge of the pool is perfectly level: the levels at the bottom are unimportant.

An ideal goldfish farm of raised ponds is here illustrated. It consists of a dozen rearing or nursery ponds, two growing ponds and a stock pond. The rearing ponds are fifteen feet square; the growing ponds thirty-six feet by fifteen feet and the stock pond eighty feet by thirty feet. There is also one distributing pond fifty feet by ten feet. This layout would be on slightly sloping ground. The water, from spring, stream, natural pond or lake, is conveyed through a pipe or channel to the distributing pond. The water is screened six feet from the sluice at the entrance to the pond. The screen is set at an angle of forty-five degrees. This distributing pond is also a tempering pond because the sun and air will warm the water, which will also be oxygenated, a very necessary thing if spring water be used. From this distributing pond the water is run into the rearing ponds through sluices or hatches. The ponds do not need running water, so when the ponds are full the sluices from the distributing pond are closed down. The channel conveying water to the distributing pond has an outlet controlled by a sluice; when the ponds are full this sluice is opened and the water supply is diverted before it reaches the screen. It can be run back to the stream from which it came or used for other purposes. There is an outlet also from the stock pond. Here again, when the hatch is opened, a channel will take the water released back to the stream or to other ponds.

There is, of course, the problem of very heavy and continuous rains and of floods. The ponds might overflow and many, if not all, the fish be lost. But surplus water can be got away by opening the hatches in the different tiers and the outlet hatch of the stock pond. As the water in each tier is sufficiently lowered its hatches are closed.

For cleaning purposes the ponds can be flushed out, in turn, by closing some hatches and opening others.

LAYOUT OF GOLDFISH PONDS

In this layout all the ponds are controllable under normal or

abnormal conditions. Control of water is of vital importance in fish breeding. Each pond has around it a working pathway, six feet wide. Inspection can thus be made from any side of each pond. That is the advantage of small ponds. Notice is quickly taken of any fish in trouble, which might be overlooked when dealing with a large pond, where havoc might be created by some enemy or disease and only noticed when numbers of floating dead fish appear on the surface. As with farm animals or children in the nursery, ailments or accidents occur with fish and must be attended by immediate treatment. On a fish farm, where concrete or clay ponds are used, there should be a hospital pond of earth. Seepage does not matter so long as there is no escape hole for the fish. Contact with fresh earth is good medicine for seedy fish.

With a good water supply a goldfish farm could have half a dozen or more of these layouts of ponds in order to breed on a large scale.

THE CARP FARM

The aquiculturist who establishes a carp farm should also be an agriculturist or a market gardener. The reason is that ponds used in carp culture are emptied at stated intervals and then cropped before being re-used for fish. Carp culture has made tremendous strides in the last two decades, principally throughout Europe and the United States. For many centuries the carp was the fish bred by monks in the ponds and moats belonging to the monasteries all over England and elsewhere. The carp, from the beginning of time, has been extensively cultivated in its original home in China and throughout the Far East. Although a warm-water fish, centuries of existence in Europe have acclimatized it to somewhat colder water conditions. Where there is much frost about, however, winter ponds are useful for safeguarding the fish during the dark months.

The proportion of different ponds for a carp farm are, in area, as follows:

Spawning and fry ponds ..	5 per cent.
Yearling ponds	10 per cent.
Two-year-old ponds ..	30 per cent.
Market ponds	50 per cent.
Winter ponds	5 per cent.

One of the ponds should be selected as a stock pond in which to keep the breeding fish. These are from four to seven years old and should not be artificially fed. Artificial feeding is necessary for quick growth and fattening, but experience has shown that breeding fish give best results, larger eggs—size and quantity—and more vigorous and healthy fry, if they have only natural food.

The number of ponds depends upon production plans. Pond capacity limits are (per acre of water surface) as follows:

Fry	.. twenty thousand to forty thousand.
Yearlings ..	.. one thousand to five thousand.
Two-year-olds	.. eight hundred to one thousand.
Three-year-olds	.. three hundred to four hundred.

The spawning pond is thirty feet by thirty feet or forty feet by thirty feet, with a depth sloping gradually to not more than two feet. Each pond is fitted with hatches at inlet and outlet. In order to get as clean water as possible it is advisable to have the inlet screened with a bank of fine gravel through which the water flows until the pond is full. A current of water is not necessary—if there is one it must be very gentle. The pond should be sheltered from the prevailing winds but open to the sun. The water must get as warm as possible by June. It is important that the spawning pond must have a good earth bottom; this is kept dry in the winter to allow the frosts to kill the sourness and get rid of undesirable pond life. The bottom, about this time, should also be limed. As spring approaches it should be manured and tilled.

SPAWNING AND INCUBATION

The middle of May is the time to fill the pond with water. There should be a few big stones or a rock or more in the pond for the female spawner to rub against. Along the sides of the pond lay twiggy, well-leaved branches of willow and other shrubs or trees. Place them so that the twigs and leaves are just covered by the water.

If the pond, in the first week in June, has a temperature of sixty degrees Fahrenheit or over—and the higher the better—the breeding fish can be placed in it from the keeping pond where they have been held. The keeping pond should be the coldest one on the farm.

One spawner (female) and two milters (male) are used. The female

should be larger and older than the males. If the water is really warm, spawning can be expected immediately. If the temperature is under sixty degrees it may be delayed several days.

Similarly incubation will take place in a few days if the water is warm, but in colder water it may take a fortnight or three weeks.

A mature spawner will produce five hundred thousand eggs or ova, from which there should be at least fifty thousand fry. Many of the eggs fall to the bottom of the pond and are smothered, others are not properly impregnated with milt, and of the others many are eaten by the parent fish before they can be removed from the spawning pond. When the spawning ends in the afternoon the breeding fish should be carefully netted and returned to their own pond. Meanwhile the impregnated eggs on the twigs and branches will eye and hatch out into alevins during the next few days.

For about four days after hatch they will subsist on their yolk sac and must not be fed. But immediately the yolk sac disappears the fry begin feeding. This is the most important period of their life. They must have food and plenty of it. The minute organisms generally known as Infusoria or Entomostraca; biscuit dust; a small quantity of beef blood—these are the foods to give for the first ten days. By then it is time to transfer a majority to the fry ponds. As these ponds are in the next tier there is no distance involved in the move. But great care must be taken in catching and removing the fry, they are very tender at this early age—even a raindrop will kill. The water in the pond can be lowered and fine trap nets used or a gauze net or even a dipper—which is a bowl with a handle. If a gentle flow is given at the inlet the fry will at once gather there and are then easily caught as they form an almost solid crowd.

The fry pond, say thirty feet by forty feet, is from one to two feet deep and will accommodate from three thousand to six thousand fry. Like other ponds it should have had its turn at being dry and limed. Then, toward spring manured, tilled and, in spring, sown with red clover. When the bottom is carpeted with the green clover towards the end of May, the pond should be filled with water. It will be a fortnight or three weeks later when the fry are turned into it. By that time, in many instances, the growth of the Entomostraca will have been so great that the water is clouded over with them. Pailfuls can be fed to the spawning and other ponds. It is sometimes

as thick as porridge. It is the natural food which the fry, at this time, require.

Other natural foods which these young fish must have can easily be produced. Details of procedures are given in Chapter XIV.

All ponds, for the young, growing fish, are shallow and broad in order to get and maintain warmth of water.

At the end of summer the fry are removed to the yearling ponds. These ponds are from eighteen inches to three feet deep. They are cropped and after harvest, usually in July, are then filled with water which, almost immediately, becomes the factor in producing natural food. The fry, which are now one inch, are placed two thousand to three thousand in each pond.

The fish will be about four inches long before winter and can be moved in the late autumn to the two-year-old ponds. If weather is very bleak and a hard winter is in prospect they can be placed in winter ponds where, with a depth of three to six feet, they will hibernate, requiring no food. Wattle hurdles or some sort of wind-brake on north and east on these winter ponds is of value. Should ice form, smallish air-holes must be broken, one in each of two corners, to allow a passage of air through the length of the pond. The two-year-old pond is shallow, from eighteen inches to two and a half or three feet. Like the other ponds it is advisable to let it lie fallow throughout the winter in alternate years and manure and till it, sowing some crop, and only fill it with water a fortnight or three weeks before fish are to be placed in it.

The young growing fish will spend their next year in the two-year-old pond.

Then, now weighing three-quarters of a pound, they will be transferred to the three-year-old pond. This move should take place in the spring of the year to give them the benefit of the growth in the pond. By autumn this pond will supply fish of two and a half pounds, the marketable size. For very many years there has been research among carp breeders everywhere on breeding strains of quick-growing fish. Nowadays, with ordinary good stock, the carp farm on the Continent produces marketable fish of two and a half pounds at the end of the third summer. In order to do this the fertility of the successive ponds must be assured and the artificial feeding, in addition, must be properly organized. The ponds are stocked according to their known

fertility. However, the numbers of fish can be increased to four times the conservative figures as laid down per acre.

It cannot be stated too often that control of the ponds on a fish farm is an absolute necessity. That is the reason for the desirability of sloping ground as a site. Here one has the gravity flow of water from one pond to another and the filling or emptying of any pond is comparatively easy. But with a more or less level site, a drainage system is imperative. The use of piping for the control of water, successfully established in the Canadian circular ponds, mentioned elsewhere in this chapter, is a system which can be adopted. The pipes are laid while the ponds are in process of excavation and construction.

CHAPTER IV

SITES, LOCATION AND SOIL

Soil is an important factor in the siting of ponds; so is accessibility to a water supply. Garden ponds or pleasure ponds are mostly of concrete and, for them, the nature of the soil is of secondary importance in siting. To the aquiculturist intending to create a fish farm of any size, from an acre or two to a hundred or more, cost is the big item, and expenditure must be carefully estimated.

Natural ponds are better for propagating all fish and plant life than artificial ponds and do not carry the expense of cement, sand and water-proofing material.

Much work has been done by scientists on investigating the bottom soils of ponds, lakes and streams, and from these studies useful knowledge for the aquiculturist is gathered. Classification is divided into the Inorganic and the Organic. In the Inorganic there is rock—from bed to rubble, gravel one-eighth to three inches in diameter, sand—both coarse and fine, clay and marl. In the Organic there is fibrous peat, pulpy peat and black muck. There are, of course, combinations of two or more of the various types of Inorganic. All these water soils, called hydrosols, are soils having water as the surface or A horizon, and the soil or bottom of pond, lake or stream is the B horizon.

THE BEST SOILS

The best soils for ponds are clay, loam, sandy or clay loam, peat or marsh bottoms. Sand, gravel or chalk in their ordinary state are considered too porous. There are many thousands of acres of waste land which can be utilized to advantage as sites for ponds. Marshy land and water meadows are other good sites. Any land broken by

gullies and ravines is a potential fish farm. Depressions in the ground, muddy water holes, shallow little valleys, would, with little labour and expense, make fish ponds.

For systematic fish culture four kinds of ponds are necessary. There is the Spawning pond, Rearing pond, Growing pond and Stock pond. The sizes of these may vary and they must be under control. Hence the importance of location. Having decided on the site, one must now decide on locating the various types of the ponds. Some may require sunlight, some shade. Again, there are others which require a combination of sun and shade. If the farm is for goldfish more sun will be required than for trout, which require more shade.

The water flow also plays a part in locating the various ponds. For goldfish, still water raises few difficulties, but for trout, some of the ponds need only a slow flow while others must have a full flow. In locating, therefore, much depends upon the water supply and its source.

Trees on a fish farm are not desirable. There are some who claim that the trees act as wind breaks and provide necessary shade. Their leaves, in the fall of the year, are a nuisance. The leaves cannot be allowed to remain in the ponds, for they quickly decay and become toxic. To get them out of the ponds means extra work. If trees are growing, in and around the sites selected for ponds, the excavating which may be, more or less, necessary, is made more difficult by the roots which extend for considerable distances. Where wind breaks are necessary for certain ponds wattle hurdles can be used. These also will give a modicum of shade. Tall water plants, mostly marginal, give practically all the needed shade.

There are numerous old quarries—also clay, chalk and gravel pits—which are plentifully supplied with water from land drainage, rain and dew. Some of these are of considerable size and nearly all are deep, forty to fifty feet and more. These can be successfully used for the culture of 'coarse' fish, a term used to distinguish various fresh-water species from game, table or aquarium fish.

To the aquiculturist such ponds are of considerable value. They are ready made, with much natural food and vegetation. The only drawback is that the water cannot be controlled. At times much water may be lost by evaporation or again heavy rains may cause overflow.

The sky or dew pond has the same disadvantages. Yet many of these 'ready-to-use' waters are very successfully operated.

IDEAL SITES

Rocky soils and swamp waste land, including marsh, are ideal sites for fish farms; though they will provide engineering problems which may be costly to overcome. The rocky soil would, no doubt, be found on a slope, and the construction of ponds might be simple. To make such a site of real value there should be, of course, a good water supply. To construct ponds on such rocky soil one must first clear the space for the bottom of each pond and then fill up fissures and other little holes and crevices with concrete. An embankment is then built all round the sides and the pond is ready for its first water.

THE SKY OR DEW POND

Sky or dew ponds are not reliable enough for extensive fish farming, but nevertheless are useful. Perfect control of ponds is the maxim in successful fish culture. Sky or dew ponds are difficult to control. With heavy rains they will overflow; with prolonged drought they may nearly dry up. The nearest approach to control is to pipe or carry water to them and arrange a good-sized soakaway in case of overflow danger. In broken or hilly country natural dew ponds are often found. Some have been successfully used by the owners or farmers of the land in which they are situated. Some natural ponds of a fair size tucked away among rolling downland or woodland may not be dew ponds but fed by a spring. These should be investigated for they could become the nucleus of a progressive, paying fish farm.

In the world of water the dew pond continues to puzzle many people and amaze others. It was, at one time, thought to be Nature's bounty to the waterless—but otherwise rich—pasturage of the downland.

It is now known that dew ponds originated in the Stone Age. Flocks of sheep, or goats maybe, cropped well on the high downlands; but always had to be driven down to the valleys for water. No doubt the shepherds of those flocks hollowed out holes, here

and there on the high points and summits of the downs, hoping to catch the rains. The earth being porous, they puddled the bottoms of those holes with clay and straw and threw in flints for good measure. Nature did the rest. In the warmth of summer the earth stored up heat while the pond was protected by the non-conductivity of the straw and, at the same time, chilled by the evaporation from the puddled clay. The condensation by night exceeded the day evaporation and, gradually, the pond began to fill and to become a proper, permanent water-hole for the downland flocks.

Now that the secret is out anyone can make a dew pond—provided they have patience and there is no limit to their time.

SWAMP AND MARSHLAND

Swamp or marshlands are usually level. In this type, when a suitable area has been selected, the first action to be taken after siting the various tiers of ponds, is to create more waterfall. There would be a source of water supply, naturally, or the site would not be chosen. This water may be from spring, stream or lake. It may be very acid, peaty, oily, sterile. On the other hand, it may be water from springs or a fast-running stream. In any event, on level ground there must be a fair water fall. This may necessitate the building of a dam or weir or the use of a ram or pump. The dam or weir would be simple, A few tree trunks and brushwood would suffice to retard the water and give a fall into a supply ditch to the ponds. Waterflow from pond to pond may have only a few inches' fall, yet that gives the flow, slow as it may be. In one reclaimed swamp a large fish farm was established by raising the bottoms of the upper tiers of ponds—in other words, terracing the whole series of tiers to the bottom tier which is on the level ground. In this way the very necessary waterfall was secured.

There are natural lakes and ponds, unused and neglected, in many of the more rural communities. Some, in waste land, are wild; some 'common' to the locality and inhabitants. Much of this forgotten water can be made, without much expense either in labour or materials, into a paradise for trout and other fish. The aquiculturist who can establish a fish farm near one or more such lakes or ponds will find it a very helpful step toward success.

ELIMINATING UNDESIRABLE FAUNA

In the past, owners of country estates containing a lake, being perhaps interested in angling, have repeatedly stocked the waters with yearling or older trout from some fish farm. But stocking is all that has been done, and in such instances the yield has been, almost invariably, poor. A few owners of water, hearkening to the progressive aquiculturist and scientific research, have lakes teeming with fine trout, which provide grand sport and good meat for the table. Stocking is not the panacea of all angling ills; the greatest care and attention must be given to environment. The fish must be assured of suitable surroundings for growth, survival, and reproduction. It is sometimes expedient to remove an entire fish population from a body of water. It is desirable to eliminate stunted populations, predatory and coarse fish, to leave room for more delectable species; again, as a means for the combating of infectious disease or even to obtain information on the relation of natural fish supplies to the inherent productive capacity of a water. To empty the lake or pond may be difficult or practically impossible. Complete elimination of a fish fauna by means of nets has never been successful; explosives are expensive and their results unpredictable. Chemicals have been tried with poor results, excepting copper sulphate. But here again the poison was found to destroy not alone the fish life but fish food organisms and plants. After much experimenting a substance was found that, in the last few years, has proved highly satisfactory on all counts. This is Derris.

For several years Derris powder has been known as an insecticide principally in horticulture. In the Middle and Far East, for some centuries, it has been used by natives for purposes of fishing. Juice from the pounded root is thrown on the water. Almost immediately stunned fish are floating on the surface and the natives, a whole village of them—men, women, and children—capture the fish, take it home, cook it and eat it. For Derris does not affect the human or warm-blooded animals. To the human nose and throat the dust from the powdered Derris is slightly irritating and anyone handling it should wear a cloth over their nostrils.

THE USE OF DERRIS POWDER

The commercial Derris (rotenone content 5 per cent) must be used in a concentration of one part in two million. The powder is mixed with water, either thin, to be administered from a watering can, or thick as a batter, to be laid on the water here and there. The rose of the can should have enlarged holes. To so treat a sizable sheet of water a boat will be necessary for spreading the Derris, and to enable one to pick up the stunned fish floating on the surface. The poison has no effect beyond twenty feet depth. It is more effective in acid than in alkaline waters; there is no damage to water plants or fish food organisms.

By this poisoning method the lake has been cleared of all its undesirables—the stunted or diseased fish, eels, pike, innumerable small coarse fish—and yet its plant life is undamaged. The effect will have disappeared from the water in forty-eight hours, but it is safer not to re-stock with trout for a week or ten days. After that the trout should have a good time and meet no opposition in their search for food. If fry of undesirable fish reappear, the trout will, undoubtedly, eat them.

While Derris powder is used extensively in other countries, it is not looked on with favour by the freshwater fishery authorities in Great Britain, particularly the angling fraternity. However, if the water to be treated has no outlet to river or stream, there should be little difficulty in getting permission to use it. Fish farmers should apply to their local Fishery Board before they undertake its use. It may be that the selected water is used by farm stock for drinking purposes, and arrangements must, therefore, be made to protect them from it for the short period required for the Derris operation.

CHAPTER V

WATER AND WATER SUPPLY

Water is the first thing to be considered in the creation of a garden pond, water-garden or a fish farm. If one is lucky enough to have a rivulet running through the grounds or a spring, a stream or river near-by, the difficulties in water supply are slight.

If the location of the ornamental pond be near the house or even within the reach of a garden hose, the matter is simple because one can use tap water. But if the pool be situated at the far end of the garden beyond the reach of the garden hose it may be necessary to use buckets. These can be filled at the end of the hose and carried to the pool. If rain water from a tank has to be used the same system of hose and buckets may also be required. When once filled in this manner, only enough water to compensate evaporation need be added for some considerable time.

In the case of the fish farm, of course, the site would have been selected in accordance with its particular demands on water supply.

There are many different waters. There is hard and soft water; acid and alkaline; warm and cold; pure and polluted; supersaturated and sub-saturated; stagnant or still and rapid or slow flowing; spring and stream; tap and rain; well water and surface water.

CONSTITUENTS OF WATER

It is better that the potential users of water in the cultivation of fish should know enough about it, without going into deep technicalities, to satisfy themselves as to the worth of the particular water involved. The gaseous constituents of water are oxygen and carbon dioxide, dissolved in the water. A punctilious chemist, discussing analysis of water, would add nitrogen to the gaseous content and

also the organic elements of Albumenoid Ammonia, Free and Saline Ammonia and Nitrites, perhaps also Chlorides. These, in an average water, are unimportant in quantity, and for purposes of judging good or bad water the indications can be safely left to the oxygen and carbon dioxide content.

Dissolved oxygen is obtained from two sources—directly from the air and from aquatic plants which, under the influence of light, emit large volumes of oxygen. This process is called photosynthesis. Like animals, plants are always using up oxygen and giving off carbon dioxide but, unlike animals, under the influence of light, they absorb carbon dioxide and emit oxygen in such quantities as to more than balance the reverse process. This plant activity accounts for the seeming anomaly that a stagnant duckpond will actually contain more oxygen than a pure spring or a mountain torrent. Temperature has a considerable influence on dissolved oxygen. The lower it is the more oxygen is absorbed from the air; the higher the temperature the less oxygen is absorbed from the air.

Water always contains ions, a positive and a negative. If these two components are identical in number then the water is absolutely pure. When positive predominates, the water is acid; when negative is in the majority, the water is alkaline. The three factors of greatest importance in water life are temperature, oxygen content and carbonic acid equilibrium. Chemistry gives the term pH to the hydrogen ions, and it is by measurement of their concentration that the condition of water can be expressed. A pH of 7 is normal water; under 7 is acid water; over 7 is alkaline water.

• MOST SUITABLE WATER FOR FISH

Water best for fish is slightly alkaline. One with a pH of about 8 is particularly suitable. The pH should not be below 6·5 or above 8·5.

A high oxygen content is necessary in ponds that are being fertilized for the purpose of providing natural food. Manures, sewage and other suitable wastes, when put into a pond, are not eaten or even touched by the fish; indeed, they are stictly avoided. However, such fertilizers are immediately attacked by bacteria and broken up. Oxygen does the rest, that is, it oxidizes the manures until they

become innocuous substances. It is the life—the zoo and phyto plankton—that emanates from these substances, which becomes the food for the fish.

It is a provision of Nature that a successful animal must be able to adapt itself to variations in its environment. Among these variations is alteration in the pressure of the atmosphere, or in the concentration of atmospheric gases, dissolved in natural waters. Fish possess this power of adaptation, and trout, considered the most sensitive of freshwater fish, have been known to live well and healthily in all sorts and conditions of water. The advised standard for fish, recommended as the normal water, is 1·0 part of oxygen per 100,000 parts of water. There are instances of waters of little oxygen content where trout thrive. But in each case there have been very small amounts of carbon dioxide in that water. It is obvious that a low oxygen concentration, of itself, in a water does not necessarily mean that such water is unfit for fish. The distribution of organisms cannot be correlated with oxygen content. There are other factors such as temperature, which must not increase, and carbon dioxide which must remain at a low figure. In wild water carbon dioxide does influence the distribution of aquatic life. Fish are unharmed by an excess of oxygen, whilst they avoid an excess of carbon dioxide which, in addition to its adverse physiological effect on the fish, encourages the germination of *Saprolegnia ferax*, which is the cause of so much damage to fish and ova. On the other hand, too little carbon dioxide is harmful to a water. Algae and other forms of plant life need carbon dioxide. If there is none the plants die, the food supply of the fish becomes exhausted and the fish either migrate if they can, or die in confined waters.

OXYGEN AND CARBON DIOXIDE

Carbon dioxide and oxygen are very dissimilar gases. Carbon dioxide is 30 per cent heavier, 15 per cent less diffusible and 40 per cent more soluble than oxygen.

There are two schools of thought among biologists, chemists, ecologists and other workers on water problems. One side is all for oxygen as the most important element in waters for fish, while the other side contends that oxygen is a secondary consideration and

that in carbon dioxide is found the true index to the degrees of purity and suitability of waters.

Having digested the scientific outpourings on this subject the fish farmer, to be on the safe side, may well secure an analysis of the water he proposes to use. If the source of his water supply be a river, stream or lake, the riparian owner of such water is sure to possess an analysis. If tap water, the waterworks will have one. The County Analyst will have many analyses of flowing waters, springs and wells in all parts of his county. Otherwise any public analyst will make an analysis from samples supplied to him.

The laws relating to waterways are many and stringent. There is no need here to refer to navigable waters. Non-navigable streams are usually owned by the landowners through whose land they flow. The term 'riparian owner' is given to such persons. If the water flows between land owned on each side by different persons, each has a right to the use of the water and half the river bed on his own side. A stream, flowing for some miles, may have dozens of riparian owners, each with his own length of water; and many of the laws refer to the action of the riparian owner in respect to the rights of those owners below and those above him.

THE LAWS ON USE OF WATER

Such laws as affect fish farmers, of which knowledge may be useful, are enumerated here.

The owner of land has an unqualified right to appropriate or drain mere casual surface water not flowing in a regular or definite course.

In case of floods an owner may take any steps to ward off a common danger and may erect fences or bulwarks in or about the stream.

If anyone acquires the right to abstract water from a natural channel for a particular purpose he cannot use it for any other purpose nor can he increase the amount agreed to be taken by enlarging ponds or channels.

Compensation water must not be foreign water or different from that in the stream.

An owner can build a dam, provided it neither gives less water to the riparian owner below, nor raises the water of the riparian owner above.

The owner has the right to use water power caused by gravitation weirs or other contrivances.

Any owner may divert the water for his own purpose, but he must return the water, substantially undiminished in volume and unaltered in character.

When water percolates up, although it may flow in underground channels beneath neighbouring land, the owner of the land from whence the spring issues, can use it, divert it, or appropriate it as he pleases.

In the case of streams issuing from the earth and flowing in a natural channel to another stream, the landowner may not divert it, but, if before it reaches the channel, it spreads on the land he may collect, divert and use it for his own. If he should build a well around the spring and from there make an artificial channel to the natural channel, he cannot appropriate the water or divert it, except if the water reaches, by percolation, the place where it issues from the earth; he may intercept the percolating water and use it as he pleases.

Every riparian owner has the right to take water from a natural stream for all ordinary purposes, such as domestic or feeding and supplying cattle on his land, etc. If, in the exercise of his ordinary rights, the water is altogether exhausted, the lower riparian owners cannot complain. But the owner cannot exhaust the water for other purposes than domestic or ordinary requirements of his land.

Besides the ordinary use of water mentioned above, a riparian owner has the right to use the water for any other purposes (which may be deemed an extraordinary use of water), provided that by so doing he does not interfere with the rights of other riparian owners above or below him.

WATER FOR ANALYSIS

In collecting a sample of water for analysis particular care should be taken to observe certain rules. The best method is to use the large glass-stoppered bottles known as Winchester Quarts. These must be clean and dry. In taking a sample from a tap or pump, the water should be allowed to run for a minute or two in order not to take water which has stood in the pipes. In ponds or lakes the sample should be taken from a few feet off the bank and a few inches below the surface. From a river or stream it should be taken about one-third

of the way across and from a spring it should be collected at the point where the water emerges from the earth. There should be no delay in delivering the sample to the analyst, as the water must be analysed within twenty-four hours of the sample being collected.

Spring water is, usually, the purest, especially when it emanates from a chalky or limestone section of the country. But spring water as a rule contains no oxygen. In some cases there is a very small amount of oxygen present and as the water emerges into the air it absorbs further slight amounts.

WATER FROM SPRINGS

Spring water is the best water for trout, both in hatching and rearing; the temperature is usually low. But, if conveyed to the ponds in an open channel via the supply pool, on a fish farm dealing with carp, goldfish, etc., it will gain the additional warmth necessary for those fish. Occasionally a spring has a mineral content which may be too pronounced for some fish. This can be tested by colour, smell and taste. It should be colourless, the taste will speak for itself and the smell can best be determined by heating the water.

Natural waters should be viewed from their environment and the geological formation through which they flow. Belts of trees or tall and dense undergrowth on the banks will help to keep temperature lower in the summer on lake or stream. A stony or gravelly bottom generally means clear water; a muddy bottom means roily water, although only slightly so, if there is a heavy covering of weed. Lake water is mostly fertile, rich in plankton and, therefore, desirable. With all such waters the test of colour, smell and taste may be a satisfactory one, yet a safer guide is to get a proper analysis.

Little brooks, rivulets, even trickling ditches may be included as streams for the supply of water to ponds; but something of the history of these smaller rivers, streams or lakes should be studied because it must be an established fact that the water is constant to a degree of supply and that it does not dry up at any time of the year.

TAP AND RAIN WATER

For garden and ornamental ponds and water gardens rain water

or tap water may be used. The rain water is soft and both in aquarium and fish pond a little chalk or lime should be used with it when first introduced. For a series of ponds the rain water can be piped from the water butts or underground tanks; for only one pond or aquarium the filling operation can be done by hand—through a hose or with buckets—changes of water being infrequent.

Tap water can be used both in ponds and aquariums and also in the water garden and in the hatchery, but with considerable caution in the case of tap water from city waterworks. In rural communities and small towns the tap water is generally pure enough in itself—coming usually from artesian wells—to make any treatment of it unnecessary. But with city water, supplied from great reservoirs of collected river and surface waters, it is necessary to purify this by chemical treatment to the standard of drinking water; usually chlorine is the chemical used. Some water engineers use 0·2 parts of chlorine to one million parts of water; others use 0·3 and 0·32 is the highest on waterworks records. There are, however, periodical surges or pulses, which elevate the chlorine content well above the levels mentioned.

Goldfish and carp are not seriously affected at the above level of 0·3, but trout and many other fish are generally killed. In fact, even smaller concentrations of free chlorine, if maintained, are toxic to trout and the less hardy water life. It is the continued presence of the chlorine in flowing water ponds and aquariums which makes it so deadly. In still water, pond or aquarium, if they be properly balanced, there is no danger, for the chlorine will quickly disappear. Many still-water aquariums use tap water. In such case it would be better to allow the water a few days to settle before putting in fish or other aquatic life.

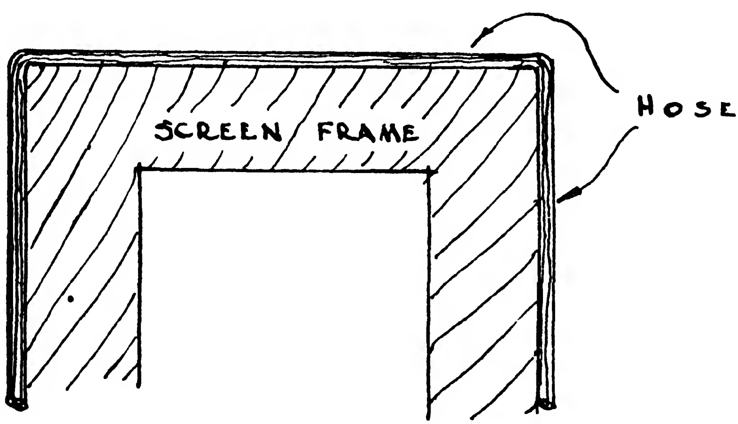
In the continuous use of tap water it is advisable to neutralize it. This can be done by dosing the water with Sodium bisulphite. The quantity used should not be less than a ratio of one part to one million parts of water. Where there is no flow the bisulphite can be stirred up in water in some container and sprinkled. Where there is a flow there is also a problem. A storage tank, containing the effluent, feeding in minute quantities with a gravity flow, is the simplest. There are several pumps and other chemical dosing apparatus specially made for this particular operation.

Sodium thiosulphate and Sodium nitrite are other reagents used for removing chlorine. The Fish Culture division of the United States Fisheries Bureau have put Sodium bisulphite first on the list not only because it is the cheapest but because 'other observers in other countries have found S. bisulphite the most efficient'.

When the supply of water is from a river, stream or lake, the legal aspects must be considered and the laws relating to these matters will give the necessary information. If land for the fish farm is bought or leased, the riparian rights should be included. If for large garden pools and water gardens, and the stream does not flow directly through the land but nearby, negotiations must be concluded with the riparian owners concerned, before such water can be used.

PIPING THE WATER

Possessing the rights, the next objective is to get the water to the site. This can be done in divers ways; by piping, by drain pipes, by channels, by ditches. It depends largely on environment. In gravel, chalk or stony land, an open channel is quite desirable. Of course,



Tight-fitting Screen

gravity is of importance. The channel need be only two feet wide. The bottom will be natural. The sides should be supported by pointed wood slabs driven into the ground to the level of the channel's sides. Battens nailed on the slabs, three or four inches from the

top, will keep them secure. The depth of the channel depends on the slope of the ground and the amount of water required. The most likely requirement will be a depth of from fifteen inches to two feet. The slab wood sides are necessary for keeping the earth of the banks from crumbling into the channel.

In clay, clay-loam or sandy-loam an ordinary ditch will convey the water to the site, but this method will necessitate more filtering and screening of the water than in the hard-bottomed, bank-protected channel.

To pipe the water through a four-inch metal pipe would be ideal for trout ponds, but it is an expensive method. Burying the pipe would keep the water cold for trout, but for goldfish or carp it could be laid in the open. A cheaper method would be to use drain pipes. By means of agricultural drain pipes, or field pipes, of terra-cotta, water could be conveyed any distance. A wire-cap screen needs to be fastened on each terminal end of the pipe line. The one is to prevent weed, earth and detritus entering the pipe line and the other to prevent entrance of any undesirable animals to block it. Care must be taken with the field pipes to see that each twelve-inch length butts properly at the joining, otherwise there is the danger of an aperture through which earth might enter and in time choke the pipe. Field pipes should be laid in straight lines in a trench.

IMPOUNDING AND COMPENSATION WATERS

Impounding and compensation waters are worth consideration. In taking the water supply from a stream, a small bay or inlet in the bank of the stream would advisably be chosen. A strong, solidly timbered sluice gate is first built into the bank within this bay or inlet; from that a wooden chute carries the water to the conveying channel. The chute need be only the length of the planks used, but must be wide enough to cover the sluice opening.

Should there not be any suitable bay or inlet, the building of a dam across the stream will impound enough water to allow the supply to be taken from there; also by way of a sluice gate and chute, into the conveying channel. Dams can be built in various ways and of various materials. In a rocky district a boulder dam may be the quickest and least expensive.

To construct a boulder dam, lay the largest available rocks or boulders, close together in a double line, across the stream bed. Drive a few piles in amongst them to give added support. Lay on rock until the desired height is reached. Additional boulders should be placed along the downstream side of the dam to prevent undercutting. To retard bank erosion the extreme ends of the dam should be higher than the mid-stream section. Stones may be chinked into the holes between the boulders and gravel thrown in on the upstream side—all of which will help to make it fairly water-tight. The water must flow over the dam. In one corner of the pool, outside the flow of the current, the sluice-gate will be erected.

Another type of dam, simple and inexpensive, is made with sacks of concrete. A weak mixture has been quite successful. This consists of one part cement, four parts sand, seven parts gravel. The mixture is packed into sacks which are then laid in a double row, lengthwise with the current; the next row is laid crossways and so on until the proper height is achieved. Piles are driven on the downstream side, and, to protect against erosion, along each bank. An apron of stout timbers, about fifteen feet long, is built against the piles on the downstream side. It is wide enough to take the water of the mid-current, flowing over the dam. The sluice-gate is fixed as already described.

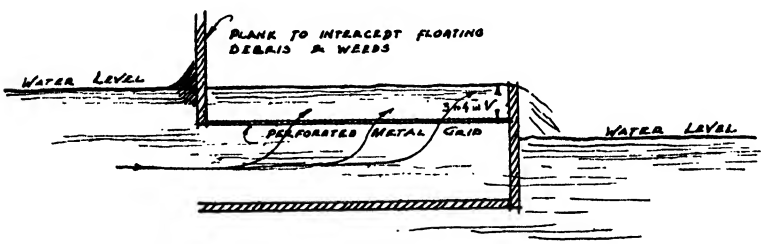
A small reservoir may be used to impound water that may be needed for compensation purposes. If there is a convenient hollow or depression in the ground this can be utilized, and filled from the river by means of a ditch or channel with proper sluice-gate. Another sluice-gate leads to a gravity channel, back to the stream or, connecting with the fish farm channel, to the ponds. Such a reservoir is undoubtedly a safeguard, but with running water in the fish farm ponds could be deemed unnecessary, because the water, used by the ponds, hatchery and raceways, would be constantly returning to the parent stream, and therefore, there would be no additional water required as compensation water for the riparian owners below. However, as a safeguard against a dry season and a low-water level in the stream, a reservoir would be, in many cases, well worth the expense.

SCREENS, GRIDS, AND GRATINGS

Screens are always of much importance and are especially so in the

conveying channels. The simplest form of weed screen—known as the perpendicular—is composed of small stakes driven into the bed of the channel at suitable distances apart, and fastened on top with a nailed batten or rail. If there is much floating weed in the supply stream, such screens will need frequent attention in clearing any weed block. To ensure the regular flow of water to the ponds a small weir should be constructed just above the weed screen leading off from the channel on one side into a ditch; in cases of heavy rain or flood and the consequent rise of water level the overflow will thus go over the weir, taking much of the weed with it.

There are other screens or gratings—known as the horizontal. These are composed of heavy wire or perforated zinc and are, generally, used together in a series of three sizes: coarse, two-inch and fine mesh.



The Roberts' Grid

The position of all such screens and gratings is several feet short of the point where the water reaches the inlet to ponds or the filter, if the water is to be filtered. A weed board or deflector is quite useful to prevent inlets and grids being choked with small floating weed, such as duckweed. The board should be about nine inches under the water and three inches above the surface and should be set at an angle to the channel or the flow.

There are many kinds of grids, but one, known as the Roberts' grid, is generally considered the safest. It is mostly employed in ponds as the outlet, especially with running water. A diagram of this grid is given. It is a box-like structure of wood, the interior divided horizontally by a sheet of perforated zinc, not less than one-sixteenth of an inch in thickness. The width of the grid depends on the width of the channel in which it is to be used. When used as an inlet or outlet to a pond the size depends upon the desired flow. The grid is

submerged. The perforated zinc is fastened in grooves and can be removed for cleaning. The use of such a grid is an insurance against the escape of fish from a pond.

Floods are always a danger against which the fish farmer must guard. If floods, from heavy rains or freshets from melting snow in hilly country, are prevalent in the district, special precautions should be taken as so much damage can be done to channels, ponds, and fish. Flood water carries much debris and accumulations of stones, sticks, mud, gravel, silt, and weed.

If there is a reservoir and it be empty, or low, opening a sluice would help to divert some of the flooding water, which could be then let off in small quantities without doing any damage. Small weirs arranged along conveying channels would also carry off some flood water.

An irrigation ditch on each side of the pond layout has been found helpful in taking flood surface water. But such precautions depend on the nature of the ground, and if the country is hilly and torrents form after heavy rains such ditches are a necessity.

If the water supply is piped and there are no open conveying channels, there is still danger to the ponds in heavy, scouring floods. Therefore a system of overflows and flood ditches should be thought out.

Screens have an important function in all ponds, raceways, etc., and sometimes trouble is caused by the fitting of the screen in the concrete outlet opening. If not perfectly snug the tiny fish will escape. By the use of old garden hose this can be remedied. Before the screen frame is put together, make a groove to take the split half of the hose. The over-all width of the frame, including the protruding portion of the hose, should be the width of the screen frame-opening, in the outlet. The hose should slide easily into the groove. When the wood expands on contact with the water, the hose takes up the expansion so that the groove becomes a tight fit.

CHAPTER VI

CONSTRUCTION WORK ON PONDS

Construction of artificial ponds is simple provided the shape is simple. The easiest, and perhaps best, shape is the rectangular or oblong with a length of twice the breadth. Round, square, octagonal are fancy shapes which require skilled labour. If a depression in the ground is being used no change need be made from the natural shape. The fullest details on construction are here given.

The initial step, after having decided on the location, the shape, and the size, is to outline the pond by inserting wooden pegs. Use a line when putting these in so as to ensure accuracy in the measurements. Allow six to eight inches extra on both sides and ends as a margin. Allow an extra foot of depth all along the bottom.

Now begins the excavating. Collect all stones in a pile. These can be used as hard core. Throw the earth up on the sides and ends to form an embankment.

There is much difference of opinion on having sloping sides or perpendicular. With sheer sides and ends, shuttering would have to be used. Sloping sides, say twenty degrees, are favoured because they help in several ways. It is easier to lay the concrete. The danger of concrete cracking in hard frosts is lessened. Marginal plants can be grown with less trouble. The argument against the sloping sides is that the water evaporates more and that the sun warms the water too quickly. For goldfish ponds the warmth is a benefit, but the greater evaporation is a disadvantage, because the water in the pond should be kept at a consistent level.

The garden pond should be three feet deep at one end, gradually sloping to six inches at the other end.

THE 'KETTLE'

Excavating being finished, work should now begin on the floor of the pond. The 'Kettle' or fish pit is not necessary in every garden pond as it is in large ponds. It will be a help, however, in cases where the pond has to be emptied or the fish netted out. Use the most accessible corner of the deep end. This pit should be from two to three feet square and two to three feet deep, depending upon the size of the pond. If the pond is not on a slope and, therefore, difficult to empty, the fish pit can also be used as a soakaway. For this dig deeper and fill up the extra space with stones, clinkers, coke or cinders. Sink a two-inch pipe, one and a half or two feet in length, in this. It must have a well-fitted plug with a ring on top. This top should be flush with the bottom of the pit. When this pipe is used for emptying the pond, put a wire gauze cap over it when removing the stopper or plug.

In making a 'natural' pond, that is of clay, place three inches of soot all along the bottom. On this place nine inches of clay. Mix straw or strawy manure with this clay and beat it down, puddling it with water. Utilize stones, brick, broken cement or any hard core and beat it hard into the clay, both at the bottom and the sides.

The soot is very necessary in that it prevents burrowing animals from creating a leak.

CEMENT PONDS

With cement ponds, begin by ramming in plenty of hard core in the bottom and sides. Then start concreting the bottom. Lay three inches of concrete. On this place expanded metal or wire netting. Then another three inches of concrete. The concrete should dry slowly; in a hot sun sprinkle occasionally with water. It must be protected from the sun and wind and kept damp for ten days. Dampened sacks or newspapers, with litter on them, are useful.

Use the same system for the ends and sides—that is a layer of concrete, then wire netting or expanded metal and then again concrete. Two inches of concrete in each layer is considered sufficient. The greatest care must be taken over the joints with the concreted bottom.

Be careful that the tops of sides and ends are level. Otherwise, when the pond is filled, the irregularity will be noticeable. Use a spirit level attached to the narrow edge of a piece of straight board long enough to cross a corner diagonally. Having levelled one corner true, mark it and start concreting there. Then level the other three corners from that.

WATERPROOFING PAINT

A finishing or smoothing mixture should then be applied over the whole of the concrete, and when this is partially dry, the whole should be painted with a waterproofing material.

The aim of all who construct concrete ponds must be to have them as perfect as possible. No leaks and no cracks are wanted. The old system in building a cement pond and before putting in plants and fish, was to allow the cement to dry. Then the pond was filled with water and emptied and filled again, and after a few days again emptied. In some cases chlorine or permanganate of potash was added to the water. All this was done to get rid of the free lime and such other toxic matter which would destroy fish and plants alike. In about six weeks the pond was considered usable. The up-to-date method abolishes all this filling and emptying. One simply puts a coating of waterproofing material upon the finished cement and in a few hours the pond is ready for planting.

There are several of these waterproofing coatings in the market under different names given by the manufacturers. All have the same useful base—bitumen. They are applied cold and on damp or dry surfaces work freely, spread easily and dry within a short time.

MIXING PAINT

The first operation is to lightly brush down the cement walls and floor so as to have them as smooth as possible. Then slightly dampen the cement with clean, cold water through a rose watering can. Mix the waterproofing material with cement. To ten gallons mix five to seven pounds of fresh Portland cement with two to three gallons of water. Mix thoroughly and keep stirred to prevent the cement from settling out. Apply this with a medium soft broom. One gallon

will cover eight square yards of concrete. If the concrete appears to be very absorbent, add clean cold water. But adhere to the figure of eight square yards per gallon of the actual waterproofing material because the diluted material will not effectively cover a greater area, and it is the effect that is required. Allow forty-eight hours for the waterproofing material to set. It will set as waterproof as rubber but will not perish.

The concrete mix is important. Much depends on its being properly proportioned and thoroughly worked before being laid.

The best mix for ponds is known as 1, 2, 3. This is based on loose cement, weighing ninety pounds per cubic foot; damp sand, eighty-four pounds per c.f., and shingle, or coarse aggregate, one hundred and nine pounds per c.f.

All the ingredients, including the water must be accurately measured. A bucket is convenient for this.

The mix is: One bucket of cement, two buckets of sand, three buckets of shingle or aggregate and just over half a bucket of water.

Mix the concrete on a clean paved floor or platform of boards. Spread the measured quantity of sand in a flat heap and dump the measured quantity of cement evenly on top of it. Then thoroughly mix the sand and cement by turning over with a shovel until the whole mass is the same colour, free from streaks of brown and grey. Measure the required quantity of shingle and spread it, in a layer, on top of the mixed sand and cement. Now mix all three ingredients together by turning over with a shovel until the coarse material has been uniformly distributed throughout the heap. At least three complete turnings are necessary.

Now for the water. Measure the correct quantity into a watering-can fitted with a fine rose. Sprinkle it slowly over the heap, stopping frequently to turn over the heap with a shovel. Continue turning over the heap until it has combined into a plastic mass of even colour and consistency. Should the mix not be fluid enough to work in well with the reinforcing wire or expanded metal, more water can be added, but the increase must be slight. The drier the mix, provided it is workable, the better the concrete.

Use British-made cement, clean sand, clean aggregate and clean water. Place the concrete within thirty minutes of mixing, tamp and

spade it well. Be sure to protect it from sun and wind and see that it is kept damp for ten days as previously stated.

When about to lay the floor of the pond if it be wet or muddy, from recent heavy rain perhaps, spread old newspapers on the floor and shovel the concrete on top of these.

Reinforcing is not absolutely necessary. But, if not used, it is advisable to lay an additional two inches of concrete on the floor and an additional inch on the walls. Expanded metal is supplied in nine-foot lengths and twenty-four gauge is the best. Wire netting is quite as serviceable and it is a good way to get rid of any old or used netting.

The construction of a concrete pond, as described, may seem elaborate work. Yet it is actually quite simple. Detail has been gone into very thoroughly for the benefit of those who may not have had any experience with concreting and cementing.

One can construct garden ponds and pools by the use of other materials, though concreting is the least expensive. A pond can be built of bricks. One layer is enough. Over the hard core, which has been rammed into the floor and sides, pour a mortar of cement and sand with sufficient water to give a workable mixture. The mix consists of one part of cement and six parts of sand. Lay the bricks in this as you spread it. When the brick-laying is completed wash the whole with a light mixture of one part of cement to two parts of sand, and later, put on the waterproofing material.

MAKING CEMENT SLABS

A pond can also be built of cement blocks or slabs, which can be bought in various sizes and thicknesses. A sufficient thickness is six inches. Before using slabs considerably more hard core should be used on the floor and rammed very hard. The slabs are placed in position in cement mortar, as with bricks, and then waterproofed.

The thickness of six inches is for large ponds with fairly deep water. For smaller garden ponds and pools a thickness of three or four inches should be quite sufficient.

These cement blocks or slabs can be made, more or less easily and quickly, at home. The first step in this is to make a mould of boards. This is practically a box without top or bottom. It should

be oblong in shape, eighteen inches long by nine inches wide. The height depends upon the proposed thickness of the slabs. The corners of one of the eighteen-inch sides should be nailed to the nine-inch ends. The other eighteen-inch side should be hinged at one end and bolted or latched at the other so as to open like a door or gate. A thin board should then be inserted to bisect the open framework. The inside of all the boards should be whitewashed or oiled. This mould should be placed upon a hard even floor of cement or wood on an outspread newspaper. It can now be filled with concrete on each side of the bisecting board. Use a trowel to smooth the top with a wash of cement. The work is now completed, the framework is opened and drawn away, ready for another filling. The finished slab will set quicker without the framework. The bisecting board can be easily removed when the concrete is dry. This board is only used to make the slabs lighter and easier to handle. In the case of two-, three- or four-inch thicknesses the bisecting board need not be used.

The mixture for thicknesses over four inches should be one, two, three. In thicknesses less than four inches the mixture should be one part of cement and three of sand. The aggregate should be riddled to one-half inch. Instructions already given regarding keeping the concrete damp for ten days and protecting it from sun and wind should be followed.

Some people admire the simplicity of a cement pond, beautified by the plants growing in and around it. Others may have more decorative ideas which, perhaps, can be satisfied by imbedding in cement mortar, coloured or figured tiles on the pond's surrounds.

A stone figure in, or at one end of the pond or ornamental water, may be picturesque, but the effect will be spoilt if more than one is given a place.

In one's own particular locality it may be difficult to procure large rocks. These may be wanted for the water garden, for waterfalls and for the ornamental pond as stepping-stones, etc. One can make these rocks at home as described in Chapter II.

It is desirable for the owner of any pond to know how many gallons of water it will hold. In the case of a fish pond the gallon capacity decides the maximum number of fish which can, advisably, inhabit a pond.

Construction Work on Ponds

MEASURING GALLON CAPACITY

The gallon is the capacity standard, wet or dry, based on the British Pound, by an Act of 1878. This defines the gallon as 'the volume of ten standard pounds of distilled water weighed in air against brass weights, both water and air at the temperature of 62 degrees Fahrenheit with the barometer at 30 inches'.

The formulas for measuring pond capacity are not elaborate. One cubic foot will contain 6·23 gallons of water and one hundred gallons of water are contained in sixteen cubic feet. For a square or rectangular pond with an even or sloping bottom multiply the length by the width by the average depth and then by 6¼. The total will give the number of gallons of water the pond will hold.

The formulas for ascertaining the gallon capacity of circular ponds are as follows:

For ponds with conical bottoms: Multiply ⅓ by 3·14, then by the radius and again by the radius, then multiply by the maximum depth. This total gives the capacity in cubic feet; multiply that by 6¼ and the result gives the gallons of water the pond will hold.

For a pond with a more or less flat bottom: Multiply 3·14 by the radius and again by the radius and then that total by the average depth. This result is the capacity in cubic feet. Multiply this by 6¼ and the final result is the gallon capacity.

The suggestion for measuring the radius twice, instead of just 'radius squared', is useful in the case of a natural round pond which no doubt, will have some irregularities in its shape. Using here two different radius lengths will bring in most of the pond surface into the calculations, and the error in gallons should be only slight.

The builders' formula (in the wording of the builders' own manual) is as follows: Multiply the diameter into itself and deduct one-fifth from the product. Then multiply the remainder by the depth and also by 6¼.

SEEPING IN PONDS

Seepage in ponds must be avoided at all costs. It may occur in natural ponds, but it is most likely in earthen ponds which have been dug out of the soil. To prevent seepage and to construct ponds

in, more or less, porous soils, a new material, called Bentonite, has been produced in America and is being extensively and successfully used there. It would appear to be a chemically-treated, pulverized colloidal clay, and is the by-product of chemical factories who also produce fertilizers. The method of using this material is simple—merely spreading it on the bottom of the pond, mixing with the earth there and then rolling. For the sides of the pond, tamp in the mixed earth and Bentonite. The earth in the pond must first be made as fine as possible by digging, sifting perhaps, and raking. In large ponds ploughs and harrows are used and a steam-roller. The quantity required per acre is one hundred tons. For small ponds, half a pound per ten square feet would be a sufficient amount. For a pond of two hundred square feet ten pounds would be needed.

CHAPTER VII

APPLIANCES

The aquiculturist, with a fish farm and hatchery, requires a number of appliances for use in the daily routine and for seasonal work. It may be a help to others interested in fish and ponds, to enumerate various appliances because these include some which can be useful in connection with the garden pond or pool, the water-garden or aquaria. Two necessary structures are mentioned first—in relation to the hatchery and fish farm. One is a lock-up storehouse, the other an open shed. These can be built against a wall of the hatchery, the store having, perhaps, a door leading directly from the hatchery. The store can be constructed with building slabs—quicker, easier and less costly than bricks. Now for the inside. There should be ample shelves which might be of the pink uralite now coming into universal use. This material comes in sheets of the thickness of three-sixteenths of an inch; eight feet by four feet or six feet by four feet. It can be sawn, nailed and generally worked like wood and is impervious to fire and water. It is made of Keen's cement and asbestos. Metal brackets should be used as supports.

The floor of the storehouse should be of cement or the bituminous flooring used in many factories.

The general idea, nowadays, is to have as little wood as possible, and any that is used must be painted. Such precautions are an insurance against fungoid spores on food, on tools and on vessels coming into contact with the hatchery fish. It is also a safeguard against rats and mice.

RESERVES OF STORES ADVISABLE

It is always advisable to have a reserve, however small, in case of

unforeseen damage or any emergency. A reserve of salt, cement, lime, rolls of meshed wire, perforated zinc, glass-tubing, black varnish, nets, screens, grids—all should have a place in the storehouse. Here, also, will be kept the tools and appliances used in the work of the outside ponds. The storehouse is the place to prepare the food, for in artificial feeding, considerable preparation is necessary. A chopping or mincing machine, a ricer, perhaps, will be wanted. The metal bins containing stored food should be arranged near the food-preparation section. The sink and water tap must also be at this end of the storehouse.

If incubation of eyed-ova in ponds is going to be carried out, there will be need for several 'Kashmir' boxes. These will only be used at their proper season and, therefore, space must be arranged for their storage on the shelves. Storage room must also be found for the fish-carriers, used when shipping fish, and for ova chests if eyed-ova is to be sold and transported. To safeguard against mishaps four thermometers, max. and min., should be distributed as follows: One affixed to the outside of store or hatchery to register the air temperature; one inside the hatchery for use in the troughs; one in the store for use in the ponds and a spare one as a reserve.

SEVERAL SIZES OF NETS

Nets will be wanted—of several sizes—and three or four, perhaps more, of each size. These will be of the dip-net variety and should be square, except the largest size, which can be either oblong or triangular with broadest rim at the front; a good size is from twenty-four to thirty inches by fourteen or sixteen inches. The smaller ones must be made of muslin, window net or cheesecloth or some similar soft but strong material, which will not retain the water—Miller's gauze, for instance. If fish, to be handy for shipment, are being kept in a stock pond of fair size and containing no vegetation, a seine or other such net will be required. These large drag nets should be made of heavy twine, for they will last longer, if given proper care, than nets of thin twine. The mesh should be—according to the size of the fish—small enough to prevent any escaping. Machine-made nets are not recommended, they are generally of thin twine and do not wear well; also, they cannot be easily repaired by hand workers.

Nets should be dried after use, especially the large ones. When damp the material is attacked by bacteria and, therefore, a preservative is needed. All nets, immediately after use, must be cleaned of any plant matter, debris or slime. Dry in the shade, sunlight tends to rot. The preservative should be used about every three months. A copper soap is manufactured which has proved useful but, as it dissolves in water, should not be used in a pond until experiments have shown that the small amount of copper is not toxic to the fish. A better preservative is a dip in creosote or in water-gas tar oil containing a twenty-five per cent solution of copper resinate. There are other formulas used by sea fishermen. These, however, entail much labour, including heating. Salt is a good protection against bacteria, and when a net is stored it should be sprinkled with salt. All this refers to twine nets and not to the muslin dip nets, which need only washing, drying, and renewing when showing signs of wear.

If beetles become a nuisance in the ponds, a few traps, including night lights, ready on the storehouse shelves, are handy. Rat traps may also be needed.

IMPLEMENTS AND TOOLS

Here are some implements which are of use especially in garden ponds and aquaria. One is a wooden forceps, made of two battens of pliable wood with flattened ends, screwed to a small block at the top. This is for picking out dead fish, bits of uneaten food or debris. Another item is a pair of scissors fastened to two long pieces of wood or stout cane, by which to snap off dead leaves from water plants. By using such implements the desired result can be obtained without disturbing anything in the pond or aquaria, or frightening the fish, as might be the case in groping about by hand.

Some lengths of rubber hose—half-inch or one inch—make good syphons. The longer the drop the faster the water will flow.

AN OPEN SHED

The outside shed, open on one side at least, is required to house the tanks or aquariums in which the fish farmer may wish to hatch

goldfish, carp or perch. If the last, there must be a flow of water through the tank—this water, unless the supply in general is very ample, can be used elsewhere. The outlet pipe, for instance, could lead into one of the ponds. The water for the goldfish or carp is still-water and should not be changed during the hatching, although some water, if of the same or warmer temperature, may be added to make up for evaporation and thus keep to the original level. These tanks need the open air but not too much light and no sun or rain.

Instead of wheelbarrows, little two-wheeled metal-bodied carts are recommended. They have solid rubber-tyred, spoked wheels, are very light in weight and very easily handled. The shed erected might be made large enough to stable one or more of these carts.

WASHED SAND OR GRAVEL

Only those utensils and tools in constant use there should be kept in the hatchery house itself. However, if there is room on one side of the house, it is well to have a few tubs containing washed sand and medium-sized washed gravel. Both of these are frequently wanted for the troughs. If urgently required, it is more convenient to have them on the spot than to fetch them from outside. The tubs should be kept replenished. If there should be no space in the hatchery the tubs can be kept in the storehouse near the communicating door.

No doubt the professional fish farmer will include some spraying appliances in his list of implements, if only for purposes of aerating the water in the hatching tanks. A stirrup-pump can serve a useful turn to all who have fish in ponds and aquaria and, also, to the water-garden owner. Aeration of water is very necessary for fish life. In dry, hot weather, water sprayed through the nozzle of a stirrup-pump freshens up the plants in the water-garden without disarranging their stems and blooms.

GALVANIZING IS NON-TOXIC

For many years the general idea prevailed among aquiculturists that galvanized wire and utensils were a source of danger to fish. This has now been proved a fallacy by very thorough research. In fact, it is definite that galvanized utensils, such as pails or cans, for

transporting fish have the advantage over tin or enamel utensils, in that they do not rust; the cost is less and the duller surface reflects less light—thus producing more normal surroundings for the fish. Rain on galvanized wire, and water on utensils, do not produce the slightest trace of any toxicity.

CHAPTER VIII

GOLDFISH

Goldfish, as pond inhabitants, are best divided into two classes—Ordinary goldfish and Fancy goldfish. The more fanciful fish, some grotesque, some fantastically beautiful are—due to the British climate—not outdoor pond dwellers. Some millions of ordinary goldfish, all over the world, are to be seen in aquarium, fountain basin, garden pool, park lake and pond. They are domestic pets, ornamental and interesting, a delight to children, a pleasure to watch, for their attractive colouring, and movements full of grace and liveliness. Where did they and where do they get their natural colouring? It is difficult to answer these questions because the colouring and the cult began thousands of years ago. Korea was the birth-place of the culture of goldfish in ponds. The Koreans, in those far-distant times, taught many forms of art and culture to the Chinese and Japanese.

Goldfish, in trade parlance called Common goldfish, are of the carp family. They have not the longevity of their carp ancestors, who can live out a century. The goldfish will live for about thirty years, sometimes a few years more. When hatched they possess the olive colouring of the carp; a few never lose it, but the majority change gradually within the first six months. The colours are a deep red, known as gold; white, known as pearl; and a combination of the two. The light coloured are known as silver fish. Goldfish are very hardy and can remain out of water for several hours if they are in moist surroundings. Provided the changes are gradual they can stand extremes of temperature. They will eat almost any kinds of food and are easily tamed. Prolific breeders, they will attempt to start a family even as yearlings. The goldfish has a long, flat-sided body, a wide, short head without scales. It has three single fins and two paired. These are the Caudal fin (tail), Anal (small fin near tail), Dorsal (on

back) and the paired Ventral fins (lower centre) and Pectoral (near head).

FANCY FISH FOR GARDEN PONDS

Of Fancy goldfish for ponds there are the Comet, the Fantail and the Shubunkin. The Comet is of American origin from a cross of Japanese stock. It was first produced about 1880. This fish is very graceful and a rapid swimmer and jumper. In the spring it will attempt to leap out of tank or pond. It has an elongated compressed body and long flowing fins. The dorsal fin is carried erect, the pectoral and ventrals droop, the anal is single and the caudal, which streams straight backward, is broad, long and deeply forked. The Comet is well coloured and particularly hardy.

The Fantail is the most popular of fancy fish for garden ponds and aquaria. It is very hardy and easy to breed and raise to market size. The colouring is rich, and it is exceedingly graceful in shape and movement. The body is of moderate length, much shorter than the common variety. The dorsal fin is high and erect, the anal is double, the caudal broad and not long and is separated vertically into two distinct parts, deeply forked. They do not droop, but stand straight backward.

The Shubunkin is the most recent addition to the varieties of fancy pond fish. It has transparent scales and is highly mottled in colouring, otherwise it has the structure and characteristics of the ordinary goldfish. While understood to be a 'throw-back' from distinguished Japanese fancy types, it has been adopted as a breed and is being extensively cultivated. The most desirable colours are blue mottled with red, orange, brown, black, and yellow. It is a hardy fish suitable for outdoor ponds.

These fancy types of pond fish come from the Asiatic and American strain of *Carassius auratus*, while the ordinary European strain is known as *Carassius carassius*. This latter strain never produced any fancy types until crossed with *Carassius auratus*.

THE CULTURE OF GOLDFISH

In the next chapter the culture of carp is described; the culture

of goldfish is on similar lines. The culture of both differs, very distinctly, from the culture of trout. The ponds for goldfish must be of still water and warm. The spawning and hatching season is during the warmer weather of May and early June. No troughs are required, only tanks or aquaria for the hatching of the eggs.

The procedure is as follows: Select your breeders, two or three males to one female. Goldfish begin breeding in their second year and continue for about six or seven years. They yield the maximum number of eggs in their third and fourth years. The female should not be less than two inches (less tail) in length. The males should be in their second year or more. If extensive breeding is contemplated one hundred and fifty to two hundred brood fish per acre would be required. This should provide thirty to fifty thousand fry per acre. Larger numbers are unprofitable, for overcrowding leads to heavy losses and also to stunted growth. Greater concentration, even up to half a million an acre, has been tried only to end in disaster.

HOW TO DETERMINE SEX

About the end of April separate the brood fish, the females in one pond, the males in another. It is difficult to distinguish sex except at the approach of the spawning season. A slight difference in contour exists in the region of the anus but it is extremely hard to discern. The female is usually shorter and fuller of body. In a female which has previously spawned the vent is somewhat protuberant. When spawning time approaches sex becomes apparent. The female carries more spawn on one side than the other and this curve in the body can be quickly recognized. The male develops tiny white tubercles or 'salt spots' on the gill plates and along the first ray of the pectoral fins. These tubercles are considered an infallible sign—but sometimes there is difficulty in seeing them as the fish may be backward and development is only partial. There may even be no tubercles on the fins and very few on the gill plates. But the males will begin chasing the females in the pond and by such actions reveal their sex. That is why it is deemed beneficial to separate the sexes at this period and thus avoid a too-early spawning. It is better to keep the fish in cool water ponds and the females in a pool or basin where there is no vegetation or stones on which they can rub and excite themselves.

During this period of separation the fish should be specially well fed.

NESTS FOR THE SPAWN

Having decided upon the spawning ponds to be used, nests should now be placed in them. These can consist of bunches of Myriophyllum tied together to form a large wheel; or a wooden frame or box. The box is made of three-quarter inch wood which is six inches wide, and the box should be of a size to fit easily into the tanks or aquaria in which it is due to be placed for the hatching of the ova. A standard size is twenty-seven inches long, twenty-four inches wide and a depth of six inches. The wood is painted with black varnish. Across the inside of the bottom of the box is nailed a piece of wire netting twelve inches wide, and in this netting are fastened grass roots, water-hyacinth roots and other water-plant roots or Myriophyllum. It is well to go over these to see that no snails are present. These boxes are placed in the ponds where the spawning is to take place, and boxes and roots must be submerged. Spawning occurs when the temperature of the water is sixty degrees Fahrenheit. This is the time to put the brood fish of both sexes into the pond or ponds prepared for their spawning. Spawn during the early part of the season is the best. Eggs are about one-sixteenth of an inch in diameter and a pale amber in colour. This grows paler, and during the next few days the eggs are difficult to see. The spawner swims over the prepared nests or the Myriophyllum circle and drops ten or twenty eggs at a time. The males are close behind fighting each other for the privilege of fertilizing the eggs. The spawner continues her swim around the pond at intervals dropping eggs on the nests. Spawning begins at daybreak and generally lasts till the middle of the afternoon. It continues day by day until the female is empty of spawn. A good medium-sized fish will give anything from five hundred to one thousand eggs in a season. Some fish have been known to spawn over two thousand. So soon as sufficient of the ova is deposited and fertilized it should be removed—box, plants and all—to the hatching tank. If allowed to remain the ova will be eaten by the parent fish or by some predatory insect or other pond inhabitant.

QUICK HATCHING DESIRABLE

The interval of time before the ova hatch out depends on temperature. It is usually from four days to fourteen. At seventy degrees Fahrenheit it should be less than a week. A quick hatching is preferred. It makes for stronger fish.

The hatching tanks should stand where some sunlight reaches them for a short period only.

The goldfish alevins will be rid of their yolk-sacs inside a week. Then, and then only, must they be fed. Infusoria, those microscopical plankton found in ditch and pond, should be the food of the tiny fish for the next ten days or a fortnight. By which time the alevins should be ready to be moved from the hatching tank or aquaria to a nursery pond where cultured natural food has been placed, or to a fertilized fry pond abounding in food. Should there not be enough natural food available, then it will have to be supplemented by artificial foods. But every particle offered to the fish must be fine. These tiny fry can be choked to death even by a daphnia somewhat larger than usual. The Chinese grow a small daphnioid crustacean that has a soft body. It is just the food for the baby goldfish and its culture is simple. Mix soya-bean meal with a small amount of well-rotted horse manure and sprinkle the mixture on the water around the banks of the pond. The soft crustaceans will soon appear.

While all fish will thrive best on natural food, artificial varieties can be fed to both goldfish and carp as explained in detail in Chapter XIII.

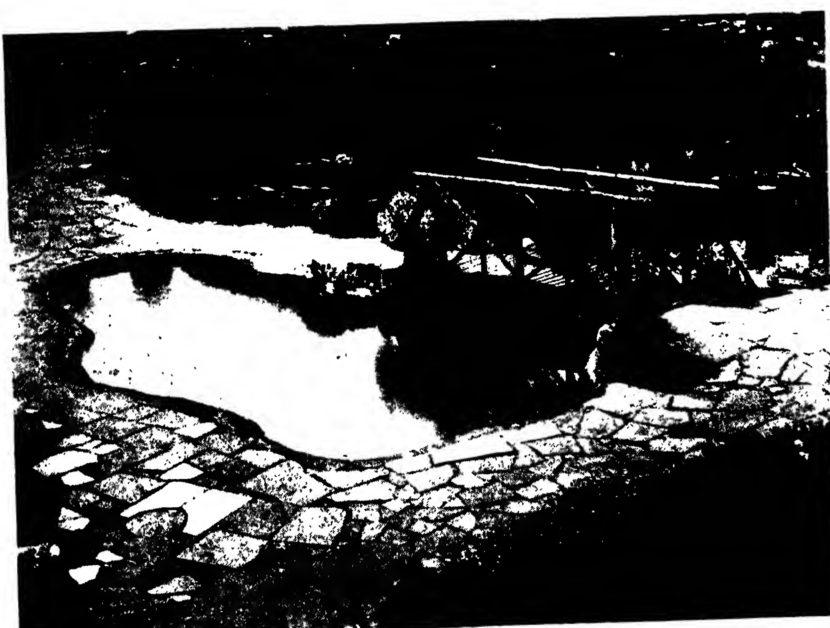
ARTIFICIAL COLOURING SECRETS

Now as to artificial colouring of goldfish practised much on the Continent. As this is a trade secret, only the general aspect of the methods can be described. The secret may be in the use of dyes insoluble in water. No doubt a chemist specializing in dyes might have some knowledge on the subject. In Britain the Home Office, in a humane forethought for the possible suffering of animals, has decreed that all experiments on or with animals shall be performed only under licence. The Home Office are very strict in this matter, and it is very difficult indeed to secure a licence.

On the Continent there would appear to be no objection to such experiments or to the practice of colouring fish by any fish farmer. A centre for artificial colouring in Continental countries consists of assembly ponds and a number of shallow cement basins. These are all situated in the open without shade or vegetation. The water in the ponds and basins is very strongly aerated by artificial means. The young fish are first placed in the assembly ponds where the heat is gradually increased by a system of hot-water pipes until a temperature of eighty-five to eighty-nine degrees Fahrenheit is reached. This temperature is maintained for the two months during which the young fish are in the assembly ponds. The feeding is very generous. Natural food as well as finely-meshed cereals are given and the fish allowed to gorge. They grow very rapidly in consequence during this period. Then comes the division of the fish. A certain number of the finest fish are selected for breeding purposes and the rest, destined for market, are removed to the colouring basins. These basins are very shallow, having a maximum depth of fifteen inches. The water in them has a maintained temperature of one hundred and four degrees Fahrenheit. This is a temperature in which one could not comfortably plunge one's hand, and at first glance, would suggest that the fish go through a terrible ordeal. Yet they seem to like it and thrive. Considering the facts and that normal human body temperature is ninety-eight degrees Fahrenheit and boiling point two hundred and twelve degrees the ordeal does not seem so terrible after all. The water in different basins are of several colours, red predominating. Others are blue, white, orange, yellow, and black. These basins contain the admixtures which do the colouring; the strength of the colouring mixture depending upon the shade of colour required. Some of the ingredients are known, such as iron (ferric salts), nut-gall and tanner's bark (tannin), but the secrets of other ingredients and the proper mixture are carefully guarded. Probably for the red colouring the pigment used in paints and known as Tuscan red may be the medium. This contains forty to to fifty per cent of ferric oxide and insoluble calcium salts.

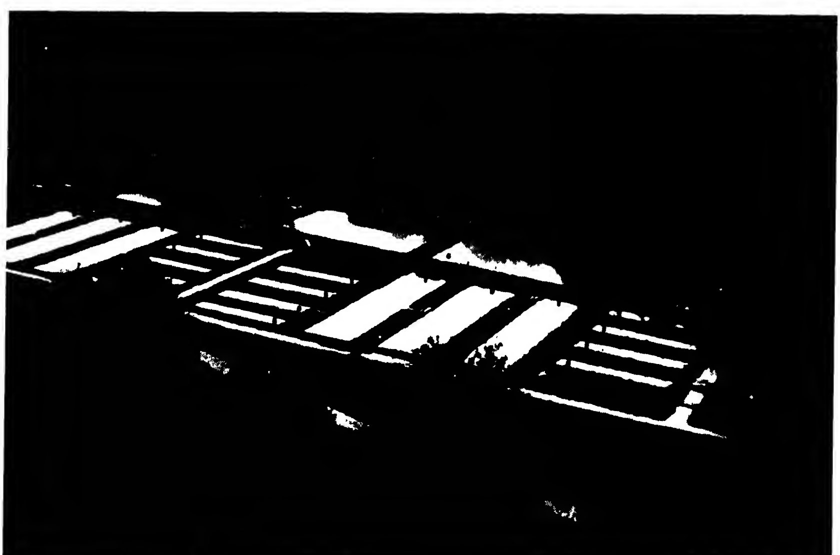
After thirty days, sometimes less, the fish, perfectly coloured, are removed to a lime-water pond, where they are hardened. After that to a succession of cooler ponds until they again reach water having a normal temperature. They are now ready for market. Death by

8. Water garden and lily pool



9. Lagoon with rock and water gardens

10. Rearing ponds at a fish farm



11. Compact lay-out of fish farm ponds

disease or misadventure at these colouring stations is infinitesimal. National colours, including tri-colours, are popular in the markets. Red, white, and blue; red, yellow, and blue; red, yellow, and black and the double colours among these, are all to be seen. How these vari-colours are attained is another secret of the art of artificial colouration.

THE XANTHOCHROISM THEORY

Now to return to Nature. The natural colour of the goldfish is used by other fish, such as the golden trout; golden tench; golden orfe; golden rudd and, very occasionally, such colouring has been seen on wild fish such as roach, carp, perch, and eels. This is due to the condition known as xanthochroism, in which only red and yellow pigments are developed in the body of the fish, the black and brown being entirely lacking. Scientists say the condition of xanthochroism may be due to the results of artificial culture. This means confinement in ponds or aquaria as against life in open waters, and receiving artificial food instead of natural wild food. If this be so, goldfish and the other golds just mentioned, may be within the category of xanthochroics. There are, usually, in a large hatching of goldfish, a few throw-backs which during their whole existence retain the colouring of the common carp. This fact would seem to be favourable to the views of the scientists on this matter. Yet, the carp, a dweller in ponds all over the world, recognized as more of a pond-fish than any other fish, only occasionally shows any sign of this condition by changing from its olive colour to gold, silver or black.

This theory of xanthochroism may be the solution to the mystery of the establishment of the goldfish as a breed by the Koreans so many centuries ago. It is known that they took small carp, made household pets of them, cultivated them in ponds and fed them artificially. It is possible to imagine them, in the matter of feeding, giving their fish a diet which contained such things as the leaves of the madder-wort, the cockle-bur and such-like yellow colour-giving plants.

In any event, the aquiculturist of to-day can thank the Koreans of two thousand years ago for giving the world the goldfish.

GOLDEN ORFE

Golden Orfe or Ide (*Idus idus*) are undoubtedly the best of ornamental pond fish, but they are somewhat difficult to rear in the English climate. This is a fish which does best if left alone. It wants a clean pond because unlike the goldfish it does not burrow in the mud. The fish originated, so far as its history goes, some centuries ago in Bavaria and is much cultivated throughout southern Germany.

Golden Orfe can be sexed when the spawning period approaches. The gonads of the female become more pronounced, while the male assumes an even more brassy colour than ordinarily and, usually, shows small tubercles. Old fish should not be chosen for mating just because of their size. Young ones from three to five years old are more vigorous and give best results. Orfe will grow to two feet in length in ten years provided the pond is a large one. They spawn best at about the same temperature as goldfish, but if at any time the 'chase' by the males is not lively the water can be slightly cooled by addition of fresh water. This should be done in the afternoon, as most of the spawning is done at night. They can be spawned indoors and outside in tanks or aquariums, but they must be large—small tanks are useless. Tie generous bunches of weed at each corner of the tank, and under each place a basin covered with meshed wire. Otherwise the fish will begin to eat the ova so soon as they have finished spawning. A certain amount of the impregnated ova will fall from the weed and be caught by the basins. These and the weed bunches can then be placed in the hatching tank or pond, to the water of which a very small quantity of salt should be added. Within six days put in some green water and infusoria as food for the emerging fry.

Because of the ova-eating habit, breeders usually lay branches of shrubs from the bank into their ponds and later remove the branches to the hatching pond. They also tie bunches of weed here and there so that they are easily removable when ready for the hatching pond. The temperature of hatching tanks and ponds must always be the same as that of the spawning ponds and tanks.

A slightly acid water with a pH of 6·7 has been found to be the best for Orfe spawning. The plants they seem to prefer to spawn on are: *Myrophilium; Anarchis; Hornwort* and smooth-leaved branches of

shrubs. *Myrophilium* is the best. For spawning the depth of water in pond or tank should not be less than two feet. One female to two males in a tank and two females to three or four males in a pond give the most profitable results.

A limestone rock or two in pond or tank is useful to the female sometimes. If there should be any signs of egg-bound condition such rocks are a necessity. Also if the signs are definite the acidity of the water can be slightly increased and also additional cold fresh water put in.

MOSQUITO ERADICATORS

Perhaps it is not generally realized, that goldfish are not only ornamental but they are also useful, especially the young ones, in eradicating mosquitoes and gnats.

There have been recorded in the British Isles twenty-eight species of insects which are popularly known as 'mosquitoes'. Now all mosquitoes belong to one of two 'tribes'—the *Anophelines*, or true mosquitoes which are carriers of such diseases as malaria; or the *Culicines* or gnats. These 'tribes' differ in several important particulars but the larval stage is the important one to consider in this instance. Larvae of all mosquitoes breathe atmospheric air and must therefore come to the water surface at frequent intervals. The larvae of *Anophelines* feed at the surface and they are provided with hooks by which they can attach themselves to plants at the water surface. *Culicines* feed either at the surface or on the dead and decaying leaves at the bottom, but they are not provided with hooks and cannot attach themselves. It follows, therefore, that *Culicines* cannot live in running water, for if they tried, they would be washed away. *Anophelines* can only live in running water provided that there are plants at the surface to which they can attach themselves.

In shallow waters such as garden pools, ornamental ponds and water gardens, mosquito and gnat larvae are to be found. The young goldfish and, in particular, their very near relatives, the Golden Orfe, will soon clear it all away. They are very fond of such food. Then again, in rain-water tanks and barrels one can often see what are popularly known as 'wrigglers', the larvae of gnats. A couple of young goldfish or sticklebacks put in each such tank or barrel will keep it free of any 'wriggler' nuisance.

Many coarse fish—dace, roach, perch, minnows, and sticklebacks—are also eradicators of mosquito and gnat larvae, but the three-spined stickleback *Gasterosteus aculeatus* appears to be the best of them. It is very hardy, very voracious, lives happily in stagnant waters and eats mosquito larvae freely. It can be obtained anywhere and will live in pools too small for the other larger species of fish. While the golden orfe has, perhaps, the highest reputation in Britain as an eradicator, the world's champion is the American top-minnow known as *Gambusia affinis*, the mosquito fish. Being a native of Texas and the Southern States generally and, therefore, sub-tropical, it had been considered impossible of use in northern latitudes. However, a quarter of a century ago, Mosquito Abatement Boards in the northern States of America began experimenting in acclimatization of the little mosquito fish. It is now established in the States, on the Canadian border, and in Canada itself. For years it has done good work in Italy, and from there it has been exported into many continental countries, including Russia—and as far north as Moscow. Most of the malaria-infested sections of the world now import the mosquito fish. Anyone not satisfied with the work of goldfish as eradicators should import a few mosquito fish from Italy.

CHAPTER IX

CARP

There are two aims in the establishment of a carp farm. (1) to breed fish ready for market by their third summer and (2) to produce breeding trios of this quick-growing strain for own use or for sale to other fish culturists. For carp one always uses trios for parent fish—one female and two males. The female should be at least four years old, because the ova or hard roe ripens at four years. The milt or soft roe of the male ripens in the third year. There should be anything from two hundred thousand to seven hundred thousand eggs from a female, depending on conditions of temperature, weather, water, food. At established carp farms they figure on an average of at least half a million eggs per spawner.

There are several varieties of the common carp. *Cyprinus Carpio* is the name of this species. It will breed anywhere, regardless of climate and latitude. The variety, most favoured by carp farmers and the trade, is the fish called the King Carp, which has been bred for a great many years from selected parents. Environment and different feeding has made it deep-bodied or fat-bellied or with longer body than the ordinary carp.

Other varieties which the carp farmer should find worth cultivating are the Mirror Carp and the Leather Carp. The Mirror Carp is a very handsome and showy fish; most suitable for a fair-sized garden pond. It is also a good fish for the food markets. The aim of the carp farmer lies, mainly, toward the food market. To this end the better fish are those with a length only twice their breadth. Both Mirror and Leather Carp are European varieties.

The carp family, so far as pond culture is concerned, in addition to those mentioned, are the Crucian; the Grass; the Black; the Silver; the Bighead; and the Mud. The last five are Chinese. The Crucian

should be avoided. It is a nuisance, too bony for food markets and a terrific breeder. The Bighead and the Mud carp would also be useless here. While it would be difficult to import breeding trios of the Grass carp from the Far East, it may be possible to secure eyed-ova.

THE SPAWNING PERIOD

The layout of a carp farm is given in detail in Chapter III. The information now given is, therefore, confined to the management and welfare of the fish from the time of spawning onwards. First of all, the spawning period. The parent fish are in cool ponds while the spawning pond is getting warm. When the temperature of the latter has reached, either naturally or by artificial means, from sixty degrees to seventy-five degrees—the higher the better—the parent fish are removed from the cool pond to the warm one. This should be during the last week in May or the first week in June. Spawning will take place almost immediately. Fecundation takes place outside the fish's body. Sexual organs of the female are represented by two rolls of ova, which join each other between the vent and the spine, and when ripe, occupy the largest part of the fish's abdominal cavity. As the male fish chase the female she dashes towards the bunches of twigs and leaves in the pond—or other flora which may be growing there—and swimming slowly over these she releases a stream of ova, a few seconds later another stream. In fact, there are a score or more ejections within an hour. This may continue for the whole morning and sometimes go on into the afternoon. The male fish follow the spawning and, hovering over the spot, impregnate the eggs with their milt. This has a milky appearance and curdles like milk, but is composed of microscopic spermatozoa. So quick is the follow up of the males that the eggs are impregnated as they reach the water. As may be expected very many eggs fall in the water unimpregnated and are lost in the mud or eaten by the parents or some pond intruder. With the impregnation of the egg the development of the embryo begins.

It is generally agreed that 10 per cent of a usual spawn can be expected to hatch into fry. A spawn of half a million eggs should, therefore, result in fifty thousand fry. The eggs include in their content a yolk which serves a double purpose. One part assists in the

development of the embryo and the other remains in the yolk sac which attaches itself to the belly of the embryo and supplies it with food for the first few days. It is interesting to observe how quickly the body grows. You first recognize the head and the spine. The eyes are particularly prominent. Then the heart and the blood vessels begin to act. In six to ten days, earlier if the water is very warm, the shell is broken and the fry emerges. It is transparent, extremely delicate, and has to remain quietly existing on the remains of the yolk in thė sac for another day or two. By the time this is exhausted the fry has grown much larger and much stronger. It has, moreover, got the suction and digestive organs working and is now able to move in the water and feed itself. This is a very important moment in the life of fry. There must be ample food in the pond and this food can only be microscopic fauna.

REMOVAL OF PARENT FISH

Regarding the parent fish; they must be removed from the spawning pond after the spawning, otherwise they may feast upon the ova. After netting the female, she should be examined to see whether there is still ova in the abdomen. If so, this should be gently pressed out as in artificial propagation.

The young fish on removal into the fry pond should continue to be fed on the microscopic fauna for a day or two. Then gradually, as the days lengthen, minute organisms should be introduced into the pond and by July these organisms can be big enough to be seen with the naked eyes.

CARP NOT VEGETARIAN

Many mistatements have been made in the past by mistaken scientists about the carp's habits. The carp is carnivorous, not a vegetarian. But he does not chew or masticate meat, nor vegetable matter, because he cannot. The carp's mouth is loose. He sucks in food. His snout has a pump-like suction arrangement. His masticating organs are insufficient for chewing anything before swallowing it. The carp is a bottom feeder, much like the tench. On the upper lip are two to four barbels which serve as feelers when searching on the

bottom. But he is not a scavenger. He dislikes and avoids any decayed or decaying matter.

If food in a pond is plentiful the fry will grow rapidly. On finishing the yolk sac they should be about half an inch long. A week or a fortnight later, on being transferred to a fry pond, they would be an inch or more. In a month's time the size should be two to three inches. This is the time to start sorting. Keep the smaller ones in their original fry pond and send the larger ones to other fry ponds. Until they reach the three-inch size the fry need careful handling. They are still extremely delicate, and netting and sorting into sizes disturbs them, and rough handling would kill them. The expectation, under normal conditions, is a loss of 25 per cent of fry from each hatch. But with care, fair weather and avoidance of haste, the loss may be reduced to a minimum. The rate of growth of the fry can be regulated by increasing or decreasing their number in a definite area of fertile ponds. A fertile pond is one that possesses large and continuous growth of plankton—the food of the fry. Continental records show that, after sorting, the larger fry, transferred to a separate pond, reached ten inches in length and one and a quarter pounds in weight during the following six months.

THE GRASS CARP

The habits of the Grass Carp are interesting because of its herbivorous nature. Even though it will take any kind of food that comes its way at random it prefers green grass and vegetables to any food of animal origin. All kinds of freshly-cut land grasses, weeds—if not too tough—leaves of some trees and all kinds of fresh vegetables are placed in a twenty-foot square frame in the pond. The frame is to prevent the grass, etc., from floating all over the pond. The Grass Carp, after the experience of a day or two, will come to this frame punctually for the food. During severe weather when green stuff may be difficult to procure foods like rice-bran and bean-meal are given. When well fed the growth of this fish is remarkable. Fry, at the end of the year in which they were hatched, commonly attain a length of six to ten inches and a weight of half to one pound. Some reach one foot in length with weight of one and a half pounds. If this size fish continues to grow it attains a length of two feet and four to five

pounds weight in the second year. It is not unusual for a Grass Carp of four years of age to weigh more than ten pounds. Weights of twenty and thirty pounds are quite common, and sometimes there is a fifty-pound Grass Carp in the market.

The Black Carp is a snail feeder and must be plentifully supplied with snails. It is a small feeder on other foods, but with a generous diet of snails it grows very fast, in a pond, attaining ten pounds weight in three years.

The Silver Carp is a plankton feeder. Due to the fine structure of its gill rakers it can feed on big particles as well as small ones suspended in the water. The silver carp reaches maturity early and weighing from three to four pounds in the third year bears ripe ova or sperm.

These three species can be stripped and artificially propagated. They are, particularly the Grass Carp, widely distributed from Siberia to south China and should stand up to climatic conditions in southern and south-western England. The fry of these species thrive on plankton. Duckweed, however, is considered the best food for fry of the grass carp. Unfortunately, duckweed grows rapidly in a well-fertilized pond, so much so that the fry cannot eat it quickly enough to stay its progress. This is an undesirable contingency, and as the weed becomes thick it must be cut and removed to give the nursery pond better light and ventilation.

CARP ARE LAZY, NOT SCAVENGERS

The carp is a lazy, luxury-loving fish. A placid pond with the right kind of shade-giving plants and, above all, plenty of food, makes for full enjoyment of its life. The carp has no work to do except suck in food. It would never do the housework in the pond. The accusation that the carp is a scavenger may be due to the cleanliness of carp ponds. This work is undoubtedly done by the snails, who are scavengers. Carp are fond of snails but, as already shown, can only eat them in the state of infancy when the shell of the snails are just forming and are soft. As the snail gets its hard shell the carp has, perforce, to ignore it. The consequence is that the pond is thus amply supplied with 'cleaners'.

Again, the statement that carp eats vegetable matter is, no doubt,

due to the fact that the fish can be seen nibbling away among the pond flora. But it is really nibbling at the host of tiny crustaceans and other minute organisms who make their home on the leaves and stems of the plants. The grass carp, however, is primarily a vegetarian.

The manuring of ponds with animal excreta, poultry droppings and night soil may sound disgusting to the uninitiated, but the fish do not feed on these dungs except sometimes at first out of ignorance and curiosity. They avoid the small piles made, at intervals of days, here and there in the ponds. The piles disappear very quickly, due to water action, and in their place appear swarms of infusoria and plankton, especially minute crustaceans.

A carp farm does not require a hatchery house. The culture of carp and goldfish is very similar, and the previous chapter, which gives all necessary details for the cult of the goldfish, should be followed by the carp farmer. Instead of leaving the impregnated ova in the spawning ponds they can be hatched, like goldfish ova, in special aquaria or wooden tanks. In the case of a smallish establishment with only a few ponds, such hatching is advisable. From the aquaria the fry will, in due course, be removed to the fry pond.

SECRET OF GROWTH

The secret of growth lies in the operative word 'plenty'. The fish, more particularly after they are removed from the nursery pond to the rearing and growing ponds, must have plenty of water, plenty of food and plenty of water-plants. The smaller ponds are the better; they must have plenty of earth on the bottom and plenty of manure. There lies the secret of fertility.

Manures should be, preferably, of animal or other organic substances. Vegetable compost also might be useful. All manures, before being put into a pond, should be thoroughly rotted. To get them into such suitable condition the manures brought to the pondside should be limed. Each forkful, as the heaps are being made, should be dusted with lime; then a good sprinkling of lime on the top. Finally, cover the heap with earth, well patted down. While waiting the week or two for the proper rotting one can use a guano manure. The Peruvian guano is practically impossible to procure, but a guano

made from poultry manure is being produced in the south of England. It is rich in nitrogen and comes in pulverized form. Before putting this in a pond it should be soaked for twenty-four hours in a container. The amounts to be used in the pond are twenty pounds (dry) per one hundred gallons of water. Over-fertility in a pond is not good for the fish, so care must be taken not to use too much manure at a time.

FIRM POND BOTTOM NECESSARY

A pond becomes fertile after manuring in that organisms are created and immediately find homes in the mud bottom or on the plant life. It is here that the carp feeds—on the bottom and among the plant life. As carp feed by sucking in their food they naturally get some earth and vegetable matter with the insects, worms or general crustaceans. This matter is not of much benefit to the fish, but it is not harmful until the pond bottom becomes too slimy. With loose slime the carp sucks up more of it than of food, and it is not only indigestible to the fish but harmful to the small fauna living in the bottom. A firm, not loose, pond bottom is desirable and necessary. That is why each season carp ponds are emptied and allowed to go dry for a period. The slime can then be scraped out and a firm bottom re-established. When empty the bottom of the pond should be ridged throughout for a time. The furrows and ridges dry quicker than if the bottom is left flat.

For some hundreds of years carp farms have existed on the Continent. German scientists, some years ago, made researches into the food for carp in Europe. For ten years they examined carp stomachs from many localities under the microscope. They found that the best natural food of the carp is the small water fauna which has no hard or tough shell. With the gullet tooth of the carp the soft shell is broken and the contents swallowed without any addition of inorganic or vegetable matter. Worms and spiders are not in favour for the carp's diet, although they will be present in the pond. Water fleas and mites and all soft-shelled crustaceans are the carp's principal choice. It needs many good mouthfuls of these minute creatures, but the water fleas must help considerably, for a famous naturalist has stated that the issue of a single water flea in two months is three

thousand millions. In a lifetime of a single female it is estimated her progeny would reach the enormous number of four and a half billions and weigh eight tons. These daphnia varieties often form a mass in the water and the carp sucks in the lot at one go. Most gnats and caddis fly are also favourite food for carp.

In ponds which do not become properly fertilized they can be colonized by removing some of the natural food from an over-fertile pond and introducing it into the under-fertilized ones.

The artificial feeding of carp is described in Chapter XIII, the chapter on food.

The three things the carp farmer should always remember, which govern growth, are food, space, temperature. Working on these principles the carp farmer will be able to market his fish at the end of the third summer from the hatching.

CHAPTER X

TROUT

The trout is not a pond fish, but it is so adaptable that it will live quite happily in a pond—provided there is a flow of water. To thrive in a pond it also requires neutral or slightly alkaline water, ample food and well-selected vegetation.

Salmon has been described as the King of Fish, but in the 340 square miles of freshwater in England and Wales inhabited by fish, in the burns of Scotland and the loughs of Ireland, the trout is the King and the acknowledged favourite for sport and table.

There is only one true trout—the British brown trout, *Salmo fario*. To distinguish the British born and bred trout from the imported *Salmo trutta*, the fish trade have changed its scientific name to *Salmo fario*. If an order be given to a fish farm or dealer for *Salmo trutta* the imported fish would be supplied, but an order for *Salmo fario* would bring along the British born and bred brown trout. As this book is largely for readers interested in fish culture and its commercial aspects, the trout's trade name is used throughout. *Fario* is used in all countries throughout the world by the trade and fish breeders to indicate the British brown trout and *trutta* to indicate the European (Continental) brown trout.

BRITISH BROWN TROUT

The British brown trout is known, and has been established, all over the world since artificial propagation became a revived industry in the last century and the travelling possibilities of eyed-ova successfully tested. In the earliest attempts to send brown trout eggs overseas, much money was spent and no success obtained. In later years, with cold-storage rooms on fast mail steamers, successful transportation

was developed, and in Ceylon, India, Australia, New Zealand, Tasmania, South Africa—among other countries—*Salmo fario* from Britain found new homes.

And thus has been created new environment varieties of the great British family of brown trout. Each environment has its own type of food and background which react on the size, condition and colour of the trout; and each produces varieties apparently differing widely one from the other. So much is this the case that naturalists made lists of as many as thirty different species alleged to exist in the British Isles and the Continent. These have now been proved to be merely different environment forms of *Salmo fario*. The most marked difference is external—just skin deep. Changes in habits are moderate. The famous Loch Leven trout and the sea trout are the best examples of environment forms of brown trout.

It is useful for the fish farmer to possess this knowledge because in marketing young fish for river stocking there will be many diversities in the new waters and habitats generally. The body temperature of a trout is not fixed, but is always one or two degrees above that of the water in which it is living. A sudden, violent change of water temperature, therefore, brings loss—either of the fish or their condition. A river, poor in food supply, after the good feeding of the fish farm; acid water after alkaline; polluted rivers; all such changes are detrimental and so the fish farmer's reputation suffers. Success in contracts with Fishery Boards and riparian owners depends a great deal on reputation.

All trout belong to the genus *Salmo*. The European brown trout bears the scientific name of *Salmo trutta*. When eyed-ova are exported from the Continent they are from so-called German brown trout. But, as already stated, almost every locality, in many, many countries, creates locality names for the varieties of the British brown trout to which it has given a home.

THE RAINBOW TROUT

Salmo fario is non-migratory; in original colour, brown or olive, with black and red spots. It has a rival, an importation from America, the Rainbow trout named *Salmo iridius*. The Rainbow is a hardy fish and can live in varied temperatures and in almost stagnant water.

As a pond fish it can be a success. Its colour is striking; blue or purple above, gold or silver below and with innumerable black spots and a gorgeous scarlet or orange band. According to anglers the Rainbow provides greater sport than the brown trout. It grows very fast if feeding well and can be ready for marketing earlier than the brown trout. Many trout farms cultivate Rainbows in addition to brown trout.

Here it is advisable to issue a word of warning to trout farmers. During the last half century, Rainbow eyed-ova has been exported from America to many countries, including England. The fish, hatched and reared here, after being put into rivers, soon began to disappear. Riparian owners raised the question: 'Where have the Rainbows gone?' Answers were not satisfactory. It became a puzzle. Riparian owners, spending much money in stocking their waters, enjoyed a few weeks of good sport and then—the fish simply vanish from the river. According to some authorities such fish have been Steelhead trout—an anodromous fish with habits of the salmon; that is to say, its fry, hatched and reared in freshwater, run down to the sea when reaching spawning maturity. The Steelhead is very similar in appearance to the trout which some American authorities claim as the true Rainbow. This latter fish is indigenous to the McCloud river, the principal tributary to the Sacramento river in California. This Rainbow trout takes its name, *Salmo Shasta*, from Mount Shasta, the highest peak of the mountain range dominating the valleys containing the streams in that section of California.

There has been, for many years, a controversy over the Rainbow. Opinions of experts and authorities in many countries, even in America, differ. Scientific names of Rainbow trout are *Salmo gairdneri*, *Shasta* and *iridius*.

So far as the culture of the Rainbow in this country and the Continent is concerned, it has, of late years, been confined to *Salmo Shasta*.

There are many points in favour of rainbows of the Shasta type compared with brown trout. The growth is quicker, therefore they can be marketed earlier. They rise more freely in early age. They are more tolerant to warm water, oxygen deficiency and pollution. They spawn at three years of age. There is less mortality in the fry, yearlings, and two-year-olds. But there are some disadvantages too. The

Rainbow want spring-fed alkaline water to breed. The females are ripe before the males; milt from *fario* can be used but there is less fertility and more mortality in the hatching. Females have a tendency to be egg-bound. They are also weaker after spawning and are then more susceptible to fungus and disease. Sometimes death follows the spawning.

Despite these few drawbacks the culture of Rainbows has been successful at British fish farms. It is advisable for intending breeders to purchase eyed-ova rather than brood fish. In this country the *Salmo Shasta* spawn in November and December, when the ova are at their best. The fish have been known to spawn later—in January and February and even in March—but the results are poor. The *Salmo iridius* spawn in the spring in March and April and, on the Continent, May and June spawnings have been recorded.

The cultivation of the two species, *Salmo fario* and *Salmo Shasta*, on the same farm can be recommended. To all intents and purposes the culture of these two species is the same and the information given in other chapters, especially Chapter XII, applies to both.

OTHER SPECIES OF TROUT

There are two other species of trout, knowledge of which may interest the intending fish farmer but which, at present, have no market. These are Grayling and Char. The Char is scarce in England and is largely confined to Lake Windermere and other such deep waters and to the Irish loughs. There have been attempts here to cultivate the Char (brook trout variety) without success. They cannot exist in warm waters. Grayling are looked upon with disfavour by riparian owners and the trout-angling fraternity as undesirable interlopers eating trout food and trout ova. It has been said that Grayling congregate around the redds when trout are spawning in order to eat the eggs. Some aquicultural scientists claim that this statement is wrong; that in their research they have examined the stomachs of Grayling at the trout-spawning season and have not found a trace of any trout eggs. They suggest that Grayling congregate around the redds in order to capture natural food of the stream released by the disturbance of the gravel. Whichever opinion covers the truth Grayling are not cultivated here. Their breeding is not recommended

12. Lay-out of trout ponds

13. Golden orfe in a garden pond

14. Removing dead eggs

15. General view of a hatchery

unless a demand for them is specially created in the food market.

In the eastern and northern districts specially of the United States and in Canada, and also on the Continent, it is a different story—the Grayling and the Char, particularly the latter, are popular.

BROOK TROUT

The Char is variously known as Brook trout and Speckled trout. It can be, and indeed is, cultivated in ponds. This fish has been described in the history of American food and game fish as 'by far the most active and handsome of the trout, living only in the clearest, coldest and most secluded waters. No higher praise can be given to a *Salmonoid* than to say it is a Char.' Many hatcheries in Canada and the United States have undertaken selective breeding and are producing brood stock with sound heredity behind them. The characteristics developed are: early and rapid growth; early maturity and large-egg-production. The Char can be cultivated on similar lines to the brown and rainbow trout. It has small scales, deeply embedded. It has no black spots, but crimson or grey ones which are paler than the body colour. The variation in the colour of the flesh from white to deep pink has been thought to be due to different foods and environment, as in the case of other fish, but scientists claim it is a hereditary characteristic due to certain fatty constituents. Yet wild fish are less likely to be pink-fleshed than pond fish. As brook or speckled trout this fish has an excellent universal market.

The spawning season for Char is the autumn. The fish mature at two to two-and-a-half years at five to six inches in length and produce one hundred to two hundred and fifty eggs. This production increases with size until from five hundred to twenty-five hundred are spawned. A twenty-two inch fish has been known to spawn up to six thousand. Eggs of the best quality are obtained from fish that are from three to five years old. After seven years of age the egg production is not reliable. The temperature for hatching, in thirty-five to forty days, is fifty degrees Fahrenheit.

Under natural conditions brook trout make a nest by throwing up a mound of gravel in the bed of a stream when the current is swift. The eggs float into the mound and lie in its crevices until hatched. In about a month the yolk-sac is consumed and the fry emerge and

seek food. Conditions in the ponds with raceways attached, therefore should be as natural as possible. The raceway bottom must be clean gravel, neither too coarse nor too fine; with the former the Char will be unable to make its mound, with the latter, there is the danger of the eggs being smothered. There must be a swift current in the raceway which should be four feet wide and seventy-five to one hundred feet in length. There should be no vegetation in the raceway. The inlet from the pond should be open throughout the spawning season.

GIANT EMPIRE TROUT

British ova has already in the past made a name for itself all over the world. The big trout of New Zealand and Tasmania are descendants of the brown trout and rainbows hatched and reared in those lands from eyed-ova which was sent years ago from England and Scotland. A brown trout of 25¼ lb. and a rainbow of 17 lb. 10 oz., caught on rod and line, have been recorded from Tasmania. Netted brown trout, used for spawning, weighed 32 lb. and 22 lb. Rod and line catches up to 20 lb. are quite frequent. In the near future larger trout may be seen in British home waters, as eyed-ova from these immense brown trout of New Zealand and Tasmania may be imported and hatched and reared here by some adventurous pisciculturist.

A NEW GIANT TROUT

The latest discovery of giant trout comes from British Columbia. In the Kamloops and Kootenay districts of that province there are many large and deep freshwater lakes, which for many years have given much sport. The fish, supposedly land-locked salmon and known as Blue salmon, are so big that they are fished from a boat trolling spoon bait. These fish have now been identified as trout and are known as *Salmo Kamloops* or *Salmo Kootenay*. The usual size is about twenty pounds, but one has recently been caught weighing just over fifty pounds.

CHAPTER XI

CULTURE OF OTHER FISH IN PONDS

The culture of other fish in ponds—in addition to trout, carp, and goldfish—is possible and, in many instances, commercially profitable. The market lies largely with Fishery Boards and Angling Clubs for the purpose of re-stocking rivers and lakes; dealers in live bait who supply an army of anglers; fishmongers, wholesale and retail, who specialize in eels and certain types of freshwater fish for the table and also with whole-salers who supply pond fish in general to the trade. Fishery Boards re-stock their waters by purchasing direct from fish farms, or by netting rivers and other waters or, in very few instances by establish-ing their own fish farms.

Among the species for culture in ponds, the prospective fish farmer can choose from the following: eels, roach, rudd, perch bream, tench, pike, and minnows.

MULLET AND PIKE FOR THE TABLE

A new-comer to pond culture in the Western hemisphere is the mullet. This fish has been long cultivated in ponds in China and in Italy. Now the fish experts of the United States Government are attempting its propagation in America. The mullet should be a pay-ing propostion for it is one of the best of all fish for the table.

Pike are for table use only, but while spawn is plentiful the loss in hatching is immense. Some pike spawn twice in a season. Females of eleven inches in length average eight thousand ova; full-grown females produce one hundred thousand. Some of the eggs prove to be immature, others insufficiently fertilized and so on. On a four-year research, the losses each year were over 99 per cent. On such a show-ing pike farming cannot be recommended.

Culture of other Fish in Ponds

EEL FARMING POSSIBILITIES

Eels cannot be propagated, so that a fish farmer could only keep them in retaining ponds for growth and fattening for market. Growing and fattening eels for market has proved a success. The English market uses several thousand tons of eels annually. This market is supplied by eel fishermen who trap and net the rivers and estuaries and, principally, by imports from Denmark, Italy, Holland, and Ireland. The largest fish farm in the world is in Italy at Comachio on the Adriatic coast. Its main objective is eel farming, but mullet, other fish and oysters are also produced in great quantities. The water area is about three hundred square miles. This area is subdivided by walls into ponds or lakes. By a system of sluices and canals, seawater flows in on the one side and on the other freshwater from the River Po. The water in the ponds is shallow, average depth being three feet. Fauna and flora natural to brackish water is abundant. There is ample food in the ponds for the eels. They are, however, also fed with small fish. The lakes and all the ponds are connected—by the canals—with each other. At the end of the winter the lakes are at the highest level of freshwater, owing to rain and melting snow filling the River Po to almost flood flow. There is at this time low salinity in the waters of canals, lakes, and ponds. Then, spring having arrived, sluices are opened and so regulated that there is a continuous flow of this freshwater into the sea, and from the sea elvers and other fish enter the lakes. As the summer approaches this migration ends and the sluices are closed.

The level of the water drops and salinity increases. By autumn the salinity is equal to, if not greater than, the sea water. This is when the sluices are opened in the grown eel lakes and the big round-up for market takes place. The silver eels start to try to effect an escape to the sea through the inlets by which the seawater enters. By a system of barriers made of bundles of reeds supported on stakes and narrow openings the eels are shepherded on and on until finally they reach a small enclosure. Here they are easily netted and are soon on their way to market.

In Denmark the chief eel farm is only about two hundred and fifty acres in extent. It consists of shallow ponds formed by damming the mouth of a lagoon on an arm of the Baltic Sea. These ponds are about

two feet in depth. Two wind-driven pumps supply sea and freshwater as required to maintain the level and control the salinity. In general the Comachio routine of procedure is followed, but with differences, according with the smaller size of the lagoon. The feeding is mainly natural plankton and molluscs and small, unmarketable fish. The production of eels per acre is much higher than at Comachio. The factors that make this Danish eel-farm a success from a financial viewpoint are the small initial outlay and the low level of working expenses. The lagoon was not required for any purpose by the owner of that coastline land and was bought at a moderate price. Dividing into ponds, building sluices, erecting wind-pumps, etc., was all simple work and little labour is now required on the farm.

There are several small eel-fisheries in Eire and Northern Ireland—more or less paying propositions.

The establishment of a successful eel-farm is possible both in inland ponds or on the coast. The latter would appear to be more simple and entailing the least expense—but the finding of a suitable site may take time. It should be on the Atlantic or on waters washed by the Atlantic. The coasts of Dorset and Hampshire are particularly rich in foods for eels.

THE CAPTURE OF ELVERS

The life history of the eel is a most remarkable one. There has been more research on the eel by scientists of many countries than upon any other fish. Because eel larvae—of sizes from a third of an inch to three inches—were caught in the western Mediterranean and off the Atlantic coasts adjoining, it was believed that there must be spawning grounds in that vicinity. This larvae were just turning into elvers, which is the fry stage of the eel. No such larvae was, however, found in the Baltic, the North Sea, the English Channel or the eastern Mediterranean. After many years of diligent study, a Danish scientist proved the previous assumptions to be wrong, for he found that the eel has only one common spawning ground, which is in mid-Atlantic between the Azores and Bermuda. Ocean currents, especially the Gulf Stream, drift the larvae and the elver eastwards and north-eastwards. The elver takes about two years to make the journey. It finds its way up some river and in due course, if un-

captured, becomes a yellow eel. It may spend anything from three to twelve years in freshwater. Then, as a silver eel, it seeks the Atlantic again, taking two months for the journey to the breeding grounds. Male eels become silver eels in three years while females take five to seven years. At one time it was believed that the yellow and silver eel were two different species, but now it is known that there is only one freshwater species and that the silver livery is adopted by the yellow eel, preparatory to seaward migration for the purpose of breeding. The conger eel is purely a marine species. The male freshwater eel rarely grows to more than twenty inches in length and half a pound in weight, but the female may go to three or four feet and several pounds in weight. A three-foot eel usually weighs five pounds. As a food, eels are very nutritious, having a fuel value of 1,635 calories and a fat value of 32·9 per cent.

HOW TO CATCH EELS

The capture of silver eels in rivers is a simple matter. They are caught in traps, nets, and baskets. Traps have the advantage that they fish automatically. It is right and proper that the silver eels be caught, for they are on their way to the sea and they would never return to the river. The time of migration varies considerably according to the locality and the nature of the season, but the main run down the rivers is usually during the autumn floods.

Eel-baskets are made of osiers. One end has a funnel-shaped opening which makes for easy entrance but difficult exit. The baskets are baited and set on the bottom of the river.

Nets can be wing-nets or the Irish 'coghill', but many of the Dutch and Danish patterns are used. These are expensive and need considerable care.

Bobbing or clotting is the best method of rod-and-line fishing for eels. It is done chiefly at night in the summer. The bait is a large bunch of worms threaded on worsted or twine. The eels hold on from greed, or because their teeth are entangled in the worsted, and can easily be landed. Spearing or stanging is practised on eels lying in the mud. The spears are specially designed to hold the eels without wounding them.

In the early spring elvers run up many of the western rivers,

especially the Severn, in their millions. Other rivers have poor runs because of heavy pollution at their mouths. The largest elvers run first during the second spring tides in March. About nine hundred of these weigh one pound. The average weight falls off, until the last of the spring tides in the middle of May, when twelve hundred weigh one pound. Many years ago the German Fisheries Union established an elver depot on the Severn, shipping annually some five million to Germany, also large consignments to Denmark, Holland, Ireland, and East Anglia. During both of the world wars the British Government took over the depot at Epney, and the distributions of the elvers.

ELVERS AS FOOD

There are also many elvers caught by the local people for the market. Elvers are a delicious food, somewhat resembling whitebait and, with food shortages, there is an ever-increasing demand.

During the wars, especially the last one, the Government encouraged the fishing and catching of eels in all rivers and lakes, instructed the fishermen and sold Dutch and other eel nets to them. The Government also published a guide on the capture of eels which contains illustrations of the best methods: traps, baskets, nets, and other appliances. This is published by H.M. Stationery Office.

PERCH HAVE TWO USES

Perch are worth cultivating as pondfish, either to market when full grown as table fish or, when as young fry, they are food for trout in rearing ponds. The perch, for its delicate flavour and firm flesh, ranks after salmon and trout as a table fish. For market they run from one to three or four pounds in weight. There are many varieties of perch—from the common perch of Britain to the 'lates' of the Nile and the magnificent 'mesoprion' of the Far East, brilliantly coloured and with tail of gold, to the 'vacti' of the Ganges. Some of the latter attain a length of five feet. A Nile perch has been caught which weighed three hundred pounds. In Italy the perch vies with mullet for first place as a table fish.

Culture of other Fish in Ponds

PERCH ARE VERY SLOW GROWERS

Perch spawn at three years old, usually in May. They congregate in shoals, under overhanging vegetation of the ponds. The water should be clear and the bottom hard and clean. No other kind of fish whatsoever must be put in a perch pond, for perch are fish of prey and will attack fish even bigger than themselves. Perch are very prolific and very hardy, but their growth is slow. On the Continent they are sold alive in the markets, wrapped in wet moss which is sprinkled with water from time to time; any unsold are taken back to the fish farm and returned to their ponds. Perch are carnivorous and do not feed on vegetable matter. They are cannibals and eat their own ova and fry. They spawn, as so many other fish do, on plants in the pond.

There should be a gentle flow of water in the perch ponds and the depth should be somewhat greater than in most ponds, sloping from, say, three to six feet. The myriophylium nests or the shrub branches laid in the pond for the spawning, should be taken as soon as possible after the ova is deposited on them, to the tank or aquarium in which they are to be hatched. The eggs are colourless and about one-twelfth of an inch in diameter. The hatch should occur in seven to nine days at seasonal temperature. The larvae or alevins absorb yolk-sac within ten days to a fortnight. They are, when hatched, one-fifth to one-third of an inch in length, pale green in colour and with heavily pigmented eyes. When they are ready to feed the alevins should be given zoo plankton and other natural food, as near microscopic as possible. Should there be a good growth of rooted plants in the perch pond it will not be necessary to use made nests and branches for the spawning and hatching. The perch will deposit the ova on the rooted plants at intervals during the day time and, when it is seen that the females have finished spawning, all milters and spawners alike, should be removed to another pond and, in the spawning pond, nature allowed to take its course without any further interference. This saves time and labour and there will, in all probability, be a good hatch. On the other hand, the tank hatch ensures good results and no worry over enemies, though more expensive in time and labour.

TENCH BRED WITH GOLDFISH

Tench can be cultivated in the goldfish ponds. Both green and golden tench are worth keeping in ornamental ponds. Tench are bottom feeders and are useful to goldfish because they open up the pond bottom for the goldfish to feed there. Tench only appear on the higher levels of the pond in the early morning. If possible, tench should be removed to a separate pond for their spawning, as the fry is similar to goldfish fry, and sometimes, unfortunate mistakes may be made in marketing young fish. General cultivation and feeding is along the same lines as in the case of goldfish. On the Continent and among Jewish and foreign elements in this country tench are largely marketed as soup fish and considered a great delicacy.

THE ROACH MARKET

Roach can be marketed as a bait fish for pike anglers or for the stocking of coarse fish rivers and canals by angling societies or Fishery Boards. The roach needs running water and a water temperature of forty-five to fifty-five degrees. The eggs are slightly larger than those of perch and light green in colour. The spawning period is mid-May to mid-June. Hatching occurs within a fortnight. The yolk-sac is consumed in eight to ten days. The alevins are about a quarter of an inch in length and grow rapidly. The first feeding should be on phyto-plankton. After a fortnight zoo-plankton should be introduced. When about three inches in length the fry will feed exclusively on microscopic plant life. This continues until at the six-inch size the fish feed on larger plants. The pond, therefore, must be well filled with rooted and floating plants. It is an advantage to have silt in the bottom of the pond, for the older fish consume much of this as food for its carbon content. The best of all foods for roach is boiled hempseed. Not more than 15 per cent per week, of their bodily weight, should be allowed the fish. Uncooked hempseed contains an alkaloid which, being volatile, is removed by the boiling. This alkaloid is said to stupefy fish. Very wisely, therefore, the fish refuse to eat uncooked hempseed.

Culture of other Fish in Ponds

THE TIMID BREAM

Bream can be cultivated for market as a table fish. In many localities the demand is good. The pond for bream should have a vegetable silt bottom, a sluggish flow and be thickly planted with rooted plants for this fish is very timid and likes to hide amid the foliage. The eggs, transparent green, are laid on plants and are larger than those of the roach. So are the alevins. The bream grows very quickly and has attained a length of two feet. The times of spawning, hatching and consumption of yolk-sac are the same as roach. The first food must be zoo-plankton. After reaching five inches in length bream become omnivorous and feed on the larger zoo-plankton and bottom animals and the larger plants, also on silt for its carbon content.

CULTIVATION OF MINOR FISH

The *Rudd* is a vegetable feeder, which can be easily cultivated for market as an ornamental fish for garden pools. Its colouring is striking, especially that of the Golden Rudd. The cultivation is the same as for the roach.

The *Bleak* is a pearly fish and its scales are in demand for the artificial pearl industry. If a fish farmer secured a good contract from that industry it might be worth cultivating.

The *Minnow* is cultivated on the Continent for food and in America for bait. It is the favourite bait of American anglers, but the species there differ from the English variety. More than a century ago minnows were cultivated in this country for the table and held a high place at banquets. The size used was two to two-and-a-half inches. The minnow is hardy and will spawn and live in ponds with a flow of water. The depth of the pond must not be less than two feet. Aquatic plants are necessary. Minnows prefer a gravel or sand bottom rather than a chalky one. The spawning period is from May onwards. The eggs adhere to stones and hatch within a week. At the spawning season the male appears in gay colours—red breast and emerald green sides. Usually the fish is silver grey with a dark green back and darker vertical bars. The minnow is a good fish for an ornamental pond for it devours any mosquito or gnat larvae in sight. It also eats the natural fish food found in any pond. The culti-

vation can be up to two hundred thousand per acre. In winter the minnow disappears into the deeper water, reappearing in the spring.

EDIBLE FROGS

While the edible frog cannot be classed as a pond fish, it is, in France and Belgium, the principal occupant of ponds on fish farms. In this country the fish farmer might find a good market for these frogs. *Rana esculenta* is to be found in a wild state in East Anglia, descendants of imported frogs from France, nearly a century ago. Foreign workers at sugar factories in the Fens hunt for them regularly. There are two classes of these edible frogs: Grenouille de parc, which is the variety cultivated on the Continental fish farms and Grenouille de pêche, the wild variety. The latter are half the price of the cultivated frog. The breeding season is early spring—March perhaps, if weather is not too wintry. Breeding trios can be secured or tadpoles or spawn. The best variety is considered to be those from fish farms in Alsace-Lorraine.

Several attempts have been made in past years to establish an edible frog farm in the Eastern Counties. They failed because a hard winter or two practically wiped out the frogs. To flourish as they should these frogs need sun. They cannot survive with continued ice and snow conditions. However, as already mentioned, there are some survivors living a more or less free and happy life along the East Coast, especially in the Romney Marshes. It might help any intending frog farmer to make research into their life there and learn how they gain the necessary protection in winter.

CHAPTER XII

PROPAGATION OF TROUT

Why, if fish breed naturally, go to the expense and trouble of breeding them artificially?

That is a question which is often asked when trout culture is being discussed. Yet any simple student of natural history can answer it. Nature has not allowed for the demands of mankind on this favourite of freshwater fish. Trout, the world over, may make nests in rivers, streams, lakes, and pools and spawn generously. Many of the ova fail to be impregnated; many more are eaten greedily by other animals. The alevins that do emerge at the hatch are, for many days, helpless in defence against further greedy enemies. Few indeed survive to the adult stage. If thousands of millions of trout were not every year artificially hatched and reared the species might become a rarity among fish.

DISCOVERY OF ARTIFICIAL HATCHING

Scientific research and experiment evolved the successful method of artificial hatching used to-day. Although the re-discovery of artificial propagation is nearly two hundred years old it was a hundred years later that a Russian scientist, Vrasski, began his research. At that time the method was to strip the ova and milt of ripe fish into a basin or pail of water and then place the fertilized eggs into running water to hatch out. Some did hatch and some were failures. The average was 50 to 60 per cent. Vrasski studied ova and milt through his microscope. After two months' intensive work he found that the period of activity—when put into water—of the spermatozoa, of which the milt consists, is only one and a half to two minutes; after that period they were drowned. He also found that ova stripped into water begin absorbing it and that the period of absorption extends

to thirty minutes. Although in nature, spawning, fertilizing, and hatching takes place in water, Vrasski found the ova only possessed the power of being impregnated before they finished water absorption. He tried experiment after experiment but none satisfied him. At last he took a dry basin and into it expelled the ova from a trout and followed up quickly with milt spurting from a male trout. Then for a full two minutes he moved the basin around, tilting it this way and that. Then, and only then, was water introduced into the basin, enough to run off the spent milt, wash the impregnated ova and clean the basin. The result was a hundred per cent success.

Strange to say, the dry or Russian method, as it is called, was not generally adopted for very many years. Here and there, fish culturists or directors of fish hatcheries, who happened also to be scientists, welcomed the method and, gradually, introduced it into general use.

There are two ways to set about trout breeding. One, to arrange nests or redds in ponds and raceways, or allow the trout, in such waters, to make their own, by a plentiful supply of coarse gravel. In this way Nature plays the predominant part. The second way is purely artificial. The fish are stripped, ova placed in trays, and these in troughs in a hatchery.

THE HATCHERY HOUSE

There are no hard-and-fast rules as to size, shape or building materials to be used for hatchery houses. Much depends on the number of eggs to be hatched. Details, given here, of the layout of a hatchery for one hundred thousand trout ova, will be a useful guide, both to those who begin modestly in fish farming, or to those who propose to hatch several hundred thousand or even millions of ova each season. It is impossible to spend too much time and thought over the selection of the site, a good water flow and a fall being the main objectives. While spring water is the better, stream water, properly filtered, is often used. The minimum fall is five feet. A fast flow is desirable, but for one hundred thousand ova a flow of six hundred gallons per hour is sufficient. At an American hatchery near Kalamazoo, Michigan, incubating and hatching troughs are supplied from one spring which gives fifteen hundred gallons per minute! And the fry and rearing ponds are supplied from two springs which

give a combined flow of seventeen hundred gallons per minute! There is little wonder that this hatchery is known as the largest in the world.

Hatchery buildings should be of stone, brick or concrete or similar material in order to keep out frost. The roof may be of corrugated iron, tiles, slates, patent roofing sheets or thatched. There should be one central skylight or two smaller ones; the floor of concrete, with a fall of one in twenty, lengthways. The building may be of any size, but measurements suggested are forty feet by twenty feet and about twelve feet in height. There are no windows in the walls and only one door. Nowadays, with cement blocks and many other kinds of patent building blocks and roofing sheets, there should be little difficulty or expense in securing a solid and substantial hatchery house.

FILTERING THE WATER

The water from spring or stream is carried to the hatchery by buried pipe or open gulley or channel. The water first enters the filter tank, which measures four feet by four feet by four feet. This tank is made of wood, metal or concrete. It is filled to within a foot of the top with stones and coarse gravel. From the top of the gravel a two-inch pipe conveys the water to the supply tank. This tank is five feet six inches by two feet by one foot six inches and is raised on concrete bases three feet six inches from the ground. The tank can be incorporated into one corner of the hatchery by an L structure or an annex can be built against the outside wall. A four-inch pipe carries the water from this supply tank to the distributing basin, which measures sixteen feet (or less according to convenience) by two feet by sixteen inches. The hatching troughs run from the distributing basin lengthwise down the building. These troughs are fourteen feet long, twelve inches wide and seven inches deep. They are raised from the ground about two and a half feet and should have a fall of at least one and a half inches. Under the troughs are the gutters, made when the concrete floor was laid. With four troughs side by side there should be ample room between them for workers. At the head of each trough at the distributing basin there are two-inch full-way gate-valves, the most useful of valves for a hatchery.

Underneath these inlets into the trough, an apron should be fixed to within one inch of the trough bottom.

The outlet of each trough is three and a half inches from the bottom and feeds a channel which flows through a buried pipe to a small pond outside the hatchery. The water from the pond, after careful screening, flows on into the raceways and fry ponds.

HATCHING TROUGHS AND TRAYS

Each trough is divided into five sections which contain hatching trays two feet long by eleven and a half inches wide and three inches deep. These trays are raised by pegs, brackets or supports screwed or nailed into the sides of the troughs so that the bottom of the tray is two and a quarter inches above the trough bottom, and one and a quarter inches below the level of the outlet. Near the outlet there should be grooves into which a half-inch board can be slid when needed as a sluice. Between each tray a dam of half-inch board, three inches high, should be fitted in grooves so as to be removable when necessary. The trough is braced by three pieces of one and a half inches by one and a quarter inches, one near each end and one in the middle. At the lower end, in the bottom of the trough, is fitted a plug to allow of flushing out conveniently. Just above this plug a perforated zinc—or a gauze—screen should be fitted at an angle of forty-five degrees to prevent the alevins from escaping after they have hatched. The screen should fit into a groove on the base as well as the sides of the trough. It is advisable to keep the inner sides and base built up with very fine sand. The tiny fish, at this stage of their existence, are able to get through the eye of a needle. The zinc or gauze must be very fine—twenty strands to an inch.

In Nature the alevins are hatched in the dark—that is they are under the gravel of the redd. Therefore it is necessary to have a cover for each tray and thus follow Nature and keep them in the dark. These covers should be well-fitting and have a handle on top by which to lift them. They can be made of wood, asbestos sheets or suchlike material.

The capacity of the trays is five thousand eggs each. The sides of the trays are made of wood and the bottom and ends are formed of a single sheet of perforated zinc. In fastening on the zinc care must

be taken not to let the raw edges project at the sides. Two transverse one inch by half-inch strips serve both for strengthening the tray and as handles for lifting it. The perforated zinc most in use is No. 9, which is holed quarter inch by $\frac{3}{32}$ inch.

SAFEGUARDING THE HATCHERY

In the hatchery house there must be the most rigid discipline regarding cleanliness. This will prevent many losses in eggs and alevins. All troughs, trays, zinc and woodwork must be given three coats of asphaltum varnish—the 'Black Varnish' of the aquiculturist. Basins, pails, jugs, mugs, should be enamel ware. The floor, being of cement, concrete or brick, and having a fall, can be quickly cleaned by hosing. The varnish is absolutely necessary to safeguard the health of eggs and fish. It is also a help in filling up crevices and cracks in the wood used and in sealing water-tightness. Zinc should be thoroughly washed and scrubbed—because of its greasy surface—before putting on the varnish.

It is always desirable to use as highly oxygenated water as is possible in a hatchery. As spring water is the best for hatching purposes, it is necessary to move it about as much as the fall allows in order to oxygenate it. Spring water has little if any oxygen at its first contact with the open air. The little three-inch high dams on the bottom of the troughs are for the purpose of causing ripples and thus more oxygen dissolved in the water. Care must be taken to have these strips true across a level trough so that when the water is running it will form an equal current over each part of the strip. If the water runs unevenly many of the eggs may be spoiled. After the eggs have hatched the supply of water should be increased slightly.

Flow of water to a hatchery, under normal conditions, can never be too high. But one must guard against any flooding and, therefore, a waste-water pipe or channel must be constructed from the distributing basin to take off surplus water not required in the troughs to the ponds outside the hatchery. As winter is the trout breeding and hatching season, all outdoor pipes should be buried or, if exposed, properly lagged.

Care should be taken to have a completely water-tight roof, drops

of water leaking through and falling into the troughs will kill the eggs if they happen to be exposed.

While the troughs may be made of deal one and a half inches thick, the wood, whatever kind is used, should be seasoned.

Noise in a hatchery has no effect whatsoever on fish. Despite the popular stories of fish coming up in their pond to receive their dinner at the sound of a bell or bugle or a voice call, fish do not hear. They can smell and their sight is wonderful indeed. If they assemble in a rush at dinner-time, it is because they have sighted the hatchery or pond attendant, carrying the dinner pail. When they are frightened, it is for the same reason—they have sighted an unfamiliar shape approaching.

DEVICES TO HELP HATCH

In hatcheries in this and other countries many different devices are used in the troughs for hatching. Some put in one and a half to two inches of gravel, on and in which the eggs are laid. This method discards the trays, using only the troughs. The gravel need not be water-worn, but should be uniform and the size of a pea. It must be very well washed and, if possible, boiled to destroy insects and insect eggs adhering to it. Gravel, containing iron rust, is not to be used. Another device is the glass grille system. This, while old-fashioned, has many advantages though, perhaps, more laborious than later methods. To each fourteen-foot trough twenty-five thousand eggs can be placed. The grille consists of a metal frame with a strip of metal on the two sides and down the centre. These strips have a single line of holes, one-sixth of an inch in size and four holes to an inch. Into each hole is fitted a glass rod or tube. Each grille holds ninety transverse rods. On these the eggs are placed. It is impossible for the eggs to slip through, but the water is able to circulate properly. The grille rests on supports embedded in the two inches of gravel on the floor of the trough. Eggs are poured on to the glass rods from a jug or beaker containing water of the same temperature as that running in the trough. Each trough takes five grilles. About five thousand eggs to each grille is sufficient as eggs should not touch each other. To distribute the eggs uniformly the grille—under water—can be shaken, and if this is not enough a soft feather can be used, the feathery end, of course.

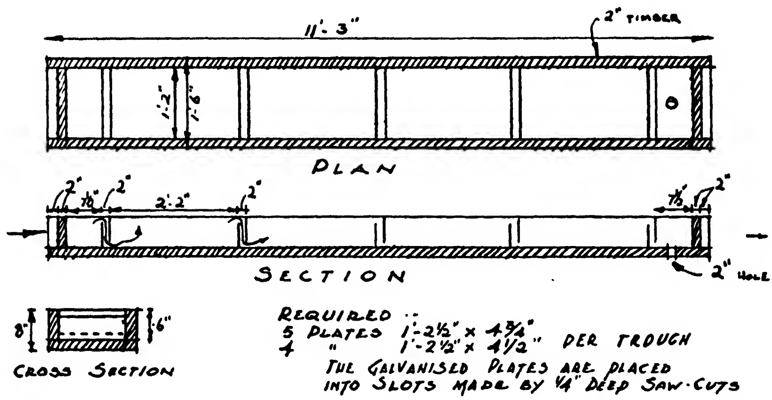
The most modern devices come from the American continent and the main points are here described.

Most of the fish breeding establishments in Canada and the United States are Government concerns and each uses the same methods in hatching. The hatcheries are mainly devoted to trout and salmon breeding. Thousands of millions of eggs are hatched every year. Consequently their methods must be such as to meet these requirements with the saving of time and labour. The United States Bureau of Fisheries has published descriptions of two of the most successful methods. In the first the troughs are sixteen feet in length; six and a half inches deep and sixteen or twelve inches wide. The troughs are arranged in pairs, and usually two or three pairs are placed end to end on different levels. The fall of water in each trough is one and a half inches. The troughs are divided by double partitions of wood or metal into compartments, just slightly longer than the baskets, to enable the latter to be raised and lowered and to be tilted slightly. The essential feature of these troughs is that at the lower end of each compartment, a partition, extending entirely across the trough, reaches from the bottom almost to the top, and another similar partition at the upper end of the compartment, reaches from the top almost to the bottom of the trough, each set of partitions being two inches apart. The water is consequently forced to flow under the upper partition and over the lower partition, and to do this it must necessarily ascend through the tray of eggs. The troughs are provided with canvas covers stretched upon light frames.

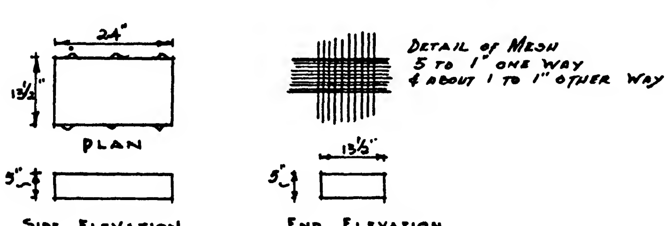
The egg receptacles are wire trays or baskets, about sixteen or twelve inches wide, twenty-four inches long and deep enough to project an inch or so above the water, which is five inches or six inches deep in the troughs in which they are placed. Into each of these baskets forty thousand eggs are poured. The eggs suffer no injury whatever from being packed together, the water being supplied in a way that forces it through the eggs, partially supporting and circulating through them. The meshes are too small to permit the eggs to pass through, although the alevins are able to do so. When eggs are simply to be matured for shipment, hatching trays with one-fourth or one-fifth square mesh will answer the purpose, but when the eggs are to be hatched in them, every alternate strand of wire running lengthways, or better still, every second and third

thread, should be left out, in order to form an oblong mesh through which the newly hatched alevins, after separating themselves from the unhatched eggs, can escape from the hatching trays into the trough below.

Where the eggs are handled by the millions, they are usually left undisturbed throughout the tender stage. When the eyes show, the baskets are lifted from the troughs and the uncovered contents of the baskets are well stirred by the hand. This procedure turns all the unfertile eggs white, and after replacing the baskets in the troughs



• The Williamson Trough (to hold 4 baskets)



for two or three days, the eggs are passed through a salt solution and the dead eggs removed by gravity. A modified method of this Williamson trough, as used in Britain, is shown in this Diagram.

The second method is used, primarily, where there is a limited flow of water, or to avoid expense of pumping, where water must be lifted mechanically, or where it is desired to hatch large numbers of trout or salmon, in a minimum number of troughs. The troughs used are fourteen feet long and twelve and $\frac{3}{16}$ inches wide by twelve

inches deep inside. The troughs are laid off in partitions as shown on sketch. Each trough has eleven compartments and each compartment accommodates ten trays, one above another, or nine trays of eggs, since no eggs are placed on the top tray. About twenty-five hundred trout eggs or about eighteen hundred salmon eggs are placed on each tray. This makes a total of about two hundred and fifty thousand trout or about one hundred and eighty thousand salmon eggs per trough. The flow of water through each trough is about eight gallons per minute. The eggs are not only left on the trays until they hatch, but the alevins also are held on the trays until their yolk sacs are absorbed, when they are transferred to feeding troughs or tanks. From time to time each stack of trays of eggs or alevins is removed and carried to a shallow trough where dead eggs, egg shells or dead alevins are removed, after which the trays are again put one above the other and replaced in the trough compartment. In many years of experience no loss from suffocation has been found and the fish produced have never shown any bad effects from this method of incubation.

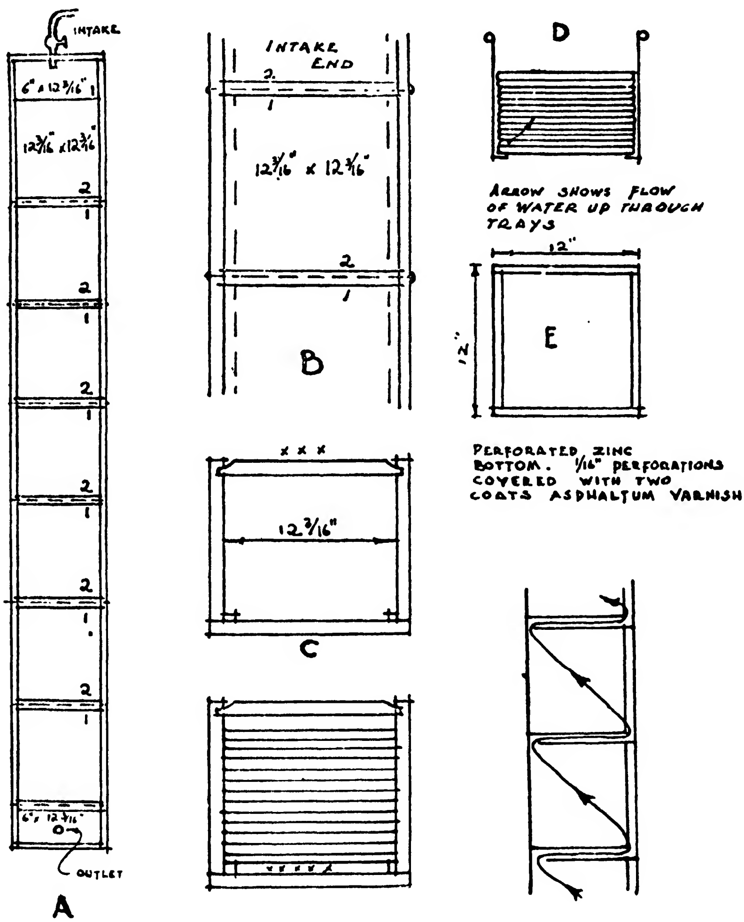
A.—shows a hatching trough. Each egg section is twelve and $\frac{3}{16}$ inches square inside and twelve inches deep. This permits stacking ten trays, nine of which contain eggs; the top tray being left empty.

1 represents galvanized iron divisions resting on end supports half an inch from bottom. 2 represents galvanized iron division resting on bottom of trough. 1 rises to quarter of an inch of top of trough. 2 rises to one inch of top of trough. Water flows under 1 and up through egg trays over 2, and then down between 1 and 2 and again up through stack of trays. Galvanized iron divisions are half an inch longer than trough is wide. Ends of 1 and 2 slide in saw cuts in sides of trough. 2 also sinks into saw cuts in bottom of trough. 1 rests on wood strip on each side, tacked to bottom of trough in such a way as to keep it half an inch from bottom. Bottom tray of each stack also rests on these same wood strips. Inside of trough is coated with asphaltum varnish.

STACKING THE TRAYS

The horizontal dotted lines in A and B indicate iron rods with locknuts on each end placed one inch from top of trough to hold

trough rigid and keep compartments exact in dimensions so that stacks of trays will not jam or bind and still be tight enough, so that water must flow up through trays and eggs. XXX at top of C represents binder that holds stack of trays tight together. Corners in bottom of C represent wood strip half inch by one inch on which



galvanized division 1 and stack of trays rest. This permits water flowing under 1 to flow under and then up through stack of egg trays.

D represents a stack of egg trays ready to be placed in a trough compartment. Note that bottom tray is fitted with a strip of No. 9

zinc, tacked to bottom of tray frame and then extends up along the side of the other trays to some distance above the top of the trough when in position. In placing the stack of trays in, or in taking the same out, of the trough, these zinc handles are grasped with the fingers, while at the same time the thumbs press down on the top tray and keep all the trays in position until the trays are in position and the tray binder is put in place. See tray binder at top of figure C. Note only that the bottom tray has strips of zinc to act as handles.

F shows flow of water up through stacks of egg trays in trough. Vertical lines indicate galvanized iron partitions.

SIMPLEST WAY OF HATCHING

There is a third method for hatching a comparatively modest number of eggs—such as fifty thousand to a hundred thousand. It is the oldest of the American methods and was devised some eighty years ago by the first of the fish culturists in that country. The system is still successfully in use. It is remarkably simple, inexpensive and, in many ways, labour-saving.

The hatchery house is twenty-four feet by thirty-two feet. It is sited so that the water supply from a spring has a good fall. The water enters the house at one of the top corners, the inlet being five square inches, and passes through a filter six feet long by one and a half feet wide by one and a half feet high. From the filter it flows in a straight line in a channel along one side of the house. This channel feeds distributing basins, five by five inches at the head of each section of troughs. The water passes from the distributing basins into the troughs by taps and the water is thus controlled.

The hatching troughs are raised two feet six inches and run, in pairs, across the building. Each trough is twenty feet long, six inches deep and fifteen inches wide. There are altogether ten troughs in five sections. The sections are separated by paths of three feet. Each of the troughs is divided into twelve compartments eighteen inches in length. The divisions are made with strips of half-inch wood two inches in height and fitted into saw cuts in the sides and bottom of the troughs. The work of a skilled carpenter is required here because of the necessity for accuracy. The bottom of the troughs is filled with gravel to a depth of one and a half inches—just half an inch below

the dividing cross piece. When this work is finished there are one hundred and twenty nests or redds on which to place eggs for hatching. The nests can take easily one thousand eggs each but, according to the method a lesser number is used. The reason is that when the hatching takes place the alevins use the troughs as their first home until the umbilical sac is used up. Eggs are laid on the gravel exactly as they are on trays or grilles. The gravel should be fine, very well washed, preferably boiled, and none over the size of a pea.

OUTDOOR INCUBATION

Incubation out of doors instead of in a hatchery house is practised more by riparian owners to restock streams than by trout farmers. The use of eyed-ova, which is nowadays increasing in favour, in hatching either inside or outside the house, lightens much of the labour and removes many difficulties.

One type of outdoor hatchery consists of a stout wooden framework stepped down, six inches to a step; carrying on each step a box made of one-inch wood, six inches high, eight inches wide and two feet six inches in length. Fitting inside each box is a zinc gauze tray, with ends and sides four inches high. The trays must not fit too closely because they must be easily removed when necessary. The inside of each box is varnished with black varnish. With six boxes on the framework, the lowest should be six inches from the ground and the top box three feet six inches from the ground. At the top of the structure, on a platform, place a barrel or large box filled with well-washed gravel and sand. Water from tap or pipe should flow into the top of this. From a tap or spout, three or more inches from the bottom of barrel or gravel box, the water should flow, in filtered condition, into the top hatching box. The flow continues from box to box until at the outlet in the last box it falls into a channel leading to a pond or other disposal place. The spouts from box to box must alternate in position—the first on the extreme right, the next on the extreme left—unless two spouts are used, one on either side. The spouts should be two inches from the top of each box, just above the gauze of the tray beneath it. The boxes must be covered to exclude too much light.

This outdoor hatchery can be placed against a wall or in the open.

The water supply must, of course, be regulated; better, perhaps, by a tap than any other device. Each tray will easily take one thousand eggs or more, so long as with a greater number, they do not touch each other. These outdoor hatcheries can be on a bigger scale by increasing the size of the stepped framework and the size, in length and breadth, of the boxes and gauze trays. The size described here is the handy size, easy to work and much used in research and experimental work. The greatest danger to the outdoor hatchery is frost. It must be watched constantly during intense freezing weather because the flow of water must never cease nor change in volume.

ADVANTAGES OF EYED-OVA

The trout farmer, if he does not buy eyed-ova, is better advised to use an indoor hatchery.

There is a wide difference between incubating ova and hatching them. The former requires skill, patience, and some practical experience; the latter can be done by almost anyone interested.

Natural spawning and hatching is also done in ponds which have a good volume and regular flow of water through them. They are, usually, long and narrow ponds, seventy-five feet by ten feet, for instance. The bottom is covered with gravel in which the spawning fish will make their own nests or redds.

Ponds can also be used for hatching eyed-ova. Artificial redds are made in the ponds and the ova placed in them. These ponds can be shallow and the flow gentle but constant in volume.

'STRIPPING' THE FISH

'Stripping' is the term used by most British aquiculturists for the artificial spawning of fish. This is the process of securing the eggs from the female and the milt from the male by gentle pressure on their bodies. Ripe fish yield up their treasures quite easily. The difficulties lie in the handling of the fish during the short operation. Stripping is the most vital spot of work in a trout farmer's year. The terms 'expression' and 'expression stripping' are largely used on the American continent, which possesses the largest number of fish hatcheries in the world and where thousands of millions of eggs are

artificially propagated. In Canada experiments in securing eggs by different methods have been made. They have proved that the gentle pressure system is the best. Female fish do not yield up all their eggs in the stripping operation. In natural spawning they drop their eggs at intervals when ripe. Usually their spawning lasts for three days, sometimes so long as six days. It was thought that eggs left in the female fish after artificial spawning might rot, set up disease and kill her. But it was found that after the stripping, on being returned to the pond, the fish would there finish her spawning.

In the Canadian experiments salmon were used. The three methods were:

Expression: twenty-five females stripped in twenty and a half minutes;

Expression and incision: thirty minutes.

Incision only: twenty-nine minutes.

In the expression plus incision method the fish was first stripped and then killed and the remaining eggs removed. In the incision method the fish was killed, bled and the eggs removed. Two men were required, instead of one for the expression method, thus making the operation more expensive. There was little difference in the number of eggs recovered.

SELECTING BREEDERS

The first step in artificial spawning is to decide on the fish to be used. These may be stock fish or wild fish or both. If the wild fish are netted from a river put them in the stock pond for a few days to watch their development towards ripeness. Trout spawn any time from late October to end of February, but usually November is the month in which a majority are ripe. One cannot tell the age of a trout from its size, but the three-year-olds are the best to use. Two-year-olds have a small amount of spawn and quite frequently a two-year-old milter is useful if male fish are not too plentiful. It is best, however, to use a three-year-old male to a female fish of from three to six years old. The female can be older than the male. Experienced breeders consider the best mating to be a four-year-old female and a three-year-old male. The milt from a male fish will fertilize ova from two or three females and has even accomplished

this satisfactorily with the ova from five. There should be at least half as many males as females in the stock pond. As to the total number it depends on how big a hatching is proposed. A trout of one pound weight will give one thousand eggs. As some of the fish may be barren, some diseased, for a hatch of one hundred thousand ova one would require at least one hundred and twenty pounds of females and sixty males in the stock pond.

As there is no vegetation nor other obstructions in the stock pond a seine net can be used to get out the fish. If not, dip nets will bring the fish to the bank. On this bank have two wooden tubs with handles, or zinc baths, of a fair size. These are half filled with fresh cold water. The netted fish must be quickly examined and tested to see if they are ripe. An expert can tell at once whether a fish is ripe, but it is advisable to make a test. Apply slight pressure to the abdomen. The eggs should flow freely. If not, put the fish back in the stock pond to ripen. The same with the male fish. Slight pressure above the vent will release a few drops of milt. If the milt is not pearly or milk-coloured it is not ripe; nor should it come out in a stream. The best milt comes out in a spurt. If its consistency is that of thick cream the fish is not yet ripe. If the fish are found to be ripe, they should be transferred to the tubs (or zinc baths)—females in one and males in the other. So soon as the stripping is completed each fish should be placed in fresh water in a bucket and at once removed to a pond—not the stock pond or pond from which it was netted. Some stripped fish may need attention. If too weak to swim on being put into the pond the fish should be gently held in running water—say at the inflow of the pond—head against the current, and it will soon recover.

DIFFERENCES IN SEX

The difference in the sexes is more apparent in the spawning season than at any other time. The male is sharper jawed than the female and lines drawn from shoulder to tail are straight without any bulge in the middle. The female's jaw is rounder and the abdomen is swollen and she has the appearance of a much larger fish than the male of the same length. The colours of the fish at this time also differ. The female is drab coloured and darker than usual while

the male's natural colours have become brilliant and intensified.

The actual spawning operation may be done on the stock pond bank or in the hatchery. If inside, the tubs of fish must be carried or conveyed immediately they have enough fish in them—say twenty females and a dozen males. But one must not forget that water weighs ten pounds a gallon—this fact must be taken into account if there is any distance from pond to hatchery.

HANDLING THE FISH

The process of spawning the fish seems simple, but it requires the greatest care and the most gentle of handling. The bowl to contain the spawn should be enamelled, twelve inches wide and six inches deep. This will hold some ten thousand eggs. Milk pans, from a dairy, will be found useful if bowls are not available.

There are several ways of handling the fish for spawning. From the female tub take up a fish by putting a hand gently in the water, moving it slowly round the fish and then lifting gently clear of the tub—it will lie quietly, in most instances, for a moment or two, water dripping from it. Then, with a flannel in the left hand grasp the fish just above the tail, the right hand holding it by the head, which should be tucked between the left arm and body. If there is a struggle do not use force but patience. If—or when—the fish is quiet, the attendant approaches with the bowl. The fish is held over this in a slightly inclined position with the vent directed toward the bowl. Now run the right hand along the abdomen of the fish from the pectoral fin towards the vent. Movement of the ova can be felt. Always follow the movement, never get in front of it. The pressure must be very gentle. If properly ripe the eggs will flow freely.

Some breeders kneel down for the operation, placing the bowl on the floor or ground. In this case, however, if a fish struggles out of the grasp and flops into the bowl which already contains ova, there is at once a small disaster and much ova, perhaps already fertilized, is destroyed. It is, therefore, better to have the bowl in the hands of an attendant, who can advance or retreat as the situation demands.

After two or three females have spawned, it is the turn of the male fish. This is a similar operation, excepting that the pressure must begin much lower down, nearer the vent. The male fish should

be held so that the milt spurts on to the ova. The bowl or pan should immediately be tilted this way and that, backward and forward, so as to get the milt to spread and contact all the ova. There is a tiny hole in each egg and in falling into the bowl the egg turns this hole upwards. A spermatozoa from the milt enters this hole, which then closes up. The impregnation is thus completed.

The contents of the bowl can also be stirred with the hand, if necessary, but it must be done very, very gently. It is a custom with some strippers to stir the bowl's contents with the tail of the fish. This should not be done. Many fish, even at that stage, have a final kick left and there have been several instances of half the impregnated contents of a bowl being destroyed with one violent swirl of the tail.

DEAD EGGS

In stripping the females a keen eye should be kept on the flow of ova to see that there are no dead eggs. Do not strip dead eggs. Put the fish back in a pond and allow her to get over her ruptured egg-sac trouble—indicated by the dead eggs. If stripped she would die, almost at once.

Some strippers, attempting to follow Nature closely, prolong the stripping to periods of three days, taking only a portion of the eggs each day. This does not seem necessary. Fish benefit rather than otherwise from the quick stripping. They suffer injury sometimes in their struggling in the hands of an inexperienced stripper. Such injury, however, is soon remedied by a few dips in a saline or chemical solution.

Special attention must continually be paid to the tubs containing the fish awaiting their turn to be stripped. The fish, breathing excitedly because of their recent capture, are extruding carbon dioxide and using up oxygen faster than usual. The tubs do not contain much water. If the fish lie quiet in the bottom of the tub, all is well; but if they come to the surface and open their mouths as if gasping for air or try to jump out, then oxygen is lacking. To avoid this situation fresh, cold water should, from time to time, be added through a watering-can rose and some of the de-oxygenated water dipped from the tub. Knowing these facts the operator should realize it calls for quick action and strip the fish as fast as possible.

The final stage in the operation is preparing the eggs for the hatchery. Cold, fresh and clean water is used, but the purpose is only the washing of the contents of the bowls. Five minutes after the last milting in a bowl, water should be added—enough to cover the ova by from half an inch to two inches. The bowl should then be covered and set aside for thirty to forty minutes, or until the eggs separate.

When first stripped from the fish the ova have adhesive properties and soon look a mere dull and sticky mass. But so soon as the milt fertilizes them they begin to change, minute by minute, and their appearance becomes less heavy. Within half an hour they seem to have lightened, become buoyant, and separate from the mass and dance about when the bowl is shaken. The separation may be accomplished within forty minutes, if the atmosphere is mild, but if the temperature is low, the adhesive power will continue and the eggs not separate for a couple of hours or even more. No harm ensues from this delay, but before the next step can be taken the ova must have separated and become individual eggs.

The next operation is the washing. Eggs are slightly heavier than water and, if movement of the bowl or pan is gentle, will remain on the bottom. Tilt the bowl or pan and let some of the water run out. Then put in fresh water and swirl the bowl around. Tilt again, and again put in fresh water. This procedure continues until one is satisfied that there is no milt, slime or dirt in the bowl and that the eggs have been most thoroughly washed to perfect cleanliness. Some put the bowls under taps, with a slow flow, occasionally swirling the bowl and emptying out half the water. All this washing may be tedious work, but it is very necessary, because of the dead milt. If any of this is left on the eggs it putrefies them and starts disease which may affect the whole hatchery. It should be noted that in pouring off the dirty water the eggs should never be quite uncovered. There should always be a little water over them. In the washing operation it is advisable to make use of the same water which is flowing through the troughs in the hatchery. This will give the eggs the right water temperature from the start.

FINAL STAGE WITH THE EGGS

In the meantime everything should be ready in the hatchery for

the reception of the eggs. The water should have been flowing through the troughs for at least two days and the trays in place. Take a bowl of eggs to a tray; tilt the bowl gently so that the water in the tray and the bowl come together with as little current as possible. Keep tilting the bowl until a sufficient number of eggs are on the tray. They will flow out easily and without injury. By moving the bowl while tilting, the eggs may be spread uniformly over the bottom of the tray. Should there be a heap here and there, a shake of the tray will disperse it. The eggs should be distributed as evenly as possible. Ova, for the first twenty-four hours, are resistant to damage by handling or movement. But after this short period they become known as 'green' ova and are very fragile and must only be moved or handled with great care and gentleness. Ova are also extremely susceptible to changes in temperature. Green ova usually will 'eye' in 21 to 26 days. It will be seen that a black spot will appear in each fertile egg. This is the eye of the embryo fish. Eyed-ova can be handled, even packed up and shipped anywhere, without suffering any harm. For they are now strong and tough and in another month's time should be hatching out alevins, as the immature trout are named.

PICKING OVER THE EGGS

Picking out dead eggs from the trays in the hatchery is a daily routine. Some breeders do this work both mornings and evenings, but once daily should suffice. The dead eggs are easily spotted because they turn white. There may also be small debris of sorts or dirt in the trays; this too must be removed. To pick out the white eggs, etc., use a plain glass tube. Place a forefinger on one end and the other end over the dead egg or object to be removed; release the finger for an instant but quickly replace it; keep it firmly on the end while lifting the tube out of the tray. The tube will now contain the egg or object. This work, of cleaning the trays of the dead, may be fairly heavy for the first day or two. After that it eases until the eggs are eyed, when the infertile eggs can be picked out. Some fish-culturists do not consider this operation necessary, knowing that the infertiles will float away in due course. But, as a safeguard against possible disease, it is better to get rid of infertiles so soon as recognized.

BEWARE OF SILT AND FUNGUS

Another little danger for eggs in the hatchery trays is sediment. This is the very fine silt always to be found in running water. The filters absorb most of it, but sometimes the finest sediment, in small quantities, gets through despite the greatest care and the best of filters. It excludes oxygen from the egg and suffocates it. If it does not kill, it so affects the embryo that it emerges weak and deformed, only to die a little later. Sediment will affect the eggs from the moment they are laid in the trays to the end of the hatching. But trouble can be easily prevented. The water used may contain very little suspended matter and after the filtering the amount of fine sediment would be negligible. If sediment is seen on any eggs, a feather can be used to gently agitate the eggs, or to make a current, by drawing the feather through the water in the tray. After the eggs are eyed, the trays can be shaken, under water, and the sediment will be washed off at once. In some hatcheries when sediment is observed, the water in the trough is lowered and, through a fine rose, the eggs are carefully sprinkled, thus washing away any sediment.

During the egg period in a hatchery there is always the fear of fungus. This is the cotton-wool like mould which appears on decaying foodstuffs and other organic substances. It is extremely infectious, spreads quickly throughout the trough and, perhaps, the whole hatchery. It is a comparatively simple matter to prevent fungus. It can be prevented by maintaining a clean and sanitary hatchery, by picking out dead eggs as often and as soon as possible, by keeping sediment and debris off the eggs. Should there be any sign of mould in any tray, then make a 3 per cent solution of salt, remove the mould, take the tray from the trough and pour the solution slowly and gently over the eggs. Then return the tray to the trough. It might also be useful to put a lump of salt on the apron in that trough and let all the trays of eggs have a brief taste. Do not use the table salt put up in packets—it may contain a dryer. Use the ordinary salt, known as sodium chloride.

MILT REQUIRES QUICK ACTION

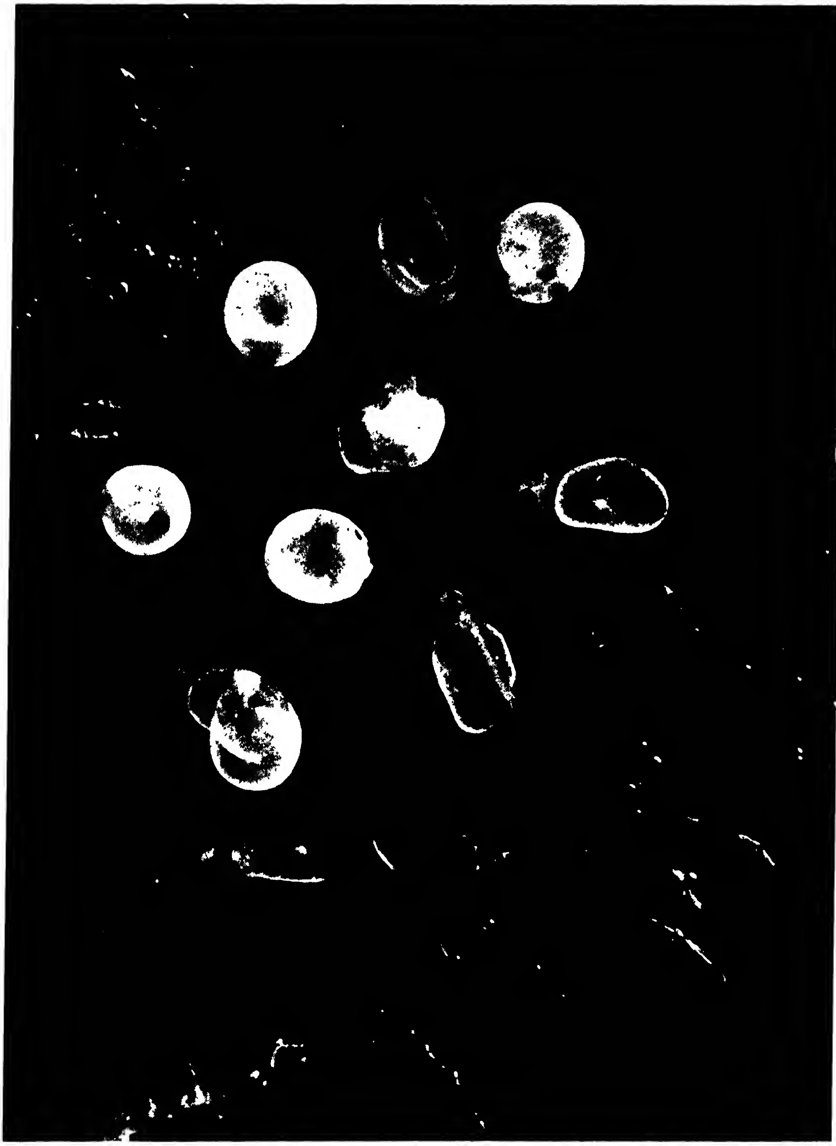
Although milt, according to temperature, has fecundation proper-

ties for such a very short time, experiments have proved that, excluded from air and moisture, it can be used successfully for some days. Put into a thermos, it impregnated ova six days later. In a glass tube, hermetically sealed, it was sent by post and used two days later. When put in a flask, sealed on top with paraffin wax, it was active five days afterwards. This knowledge may be of value to trout farms, should they have applications for milt from private individuals, who wish to hatch a few ova on their own waters. Examination under microscopes show that the myriads of spermatozoa, of which the milt consists, are most active, rushing about independently. Where male fish have been scarce, eggs have been fertilized with milt strained from other eggs that had received the milt direct from male fish. Although the period of two minutes had elapsed, it is believed that it was the extreme activity of the spermatozoa which allowed some of them to remain alive and accomplish the fertilizing. This, however, would not appear to be a safe practice, but might prove of use in extreme cases. A method which is finding favour with some breeders is to have two strippers, one for the females and one for the male and, so soon as the ova begins to emerge into the spawning bowl, to milt them. With two or three females in quick succession and a male on the spot, it is, without doubt, a time-saver when large quantities of eggs are involved.

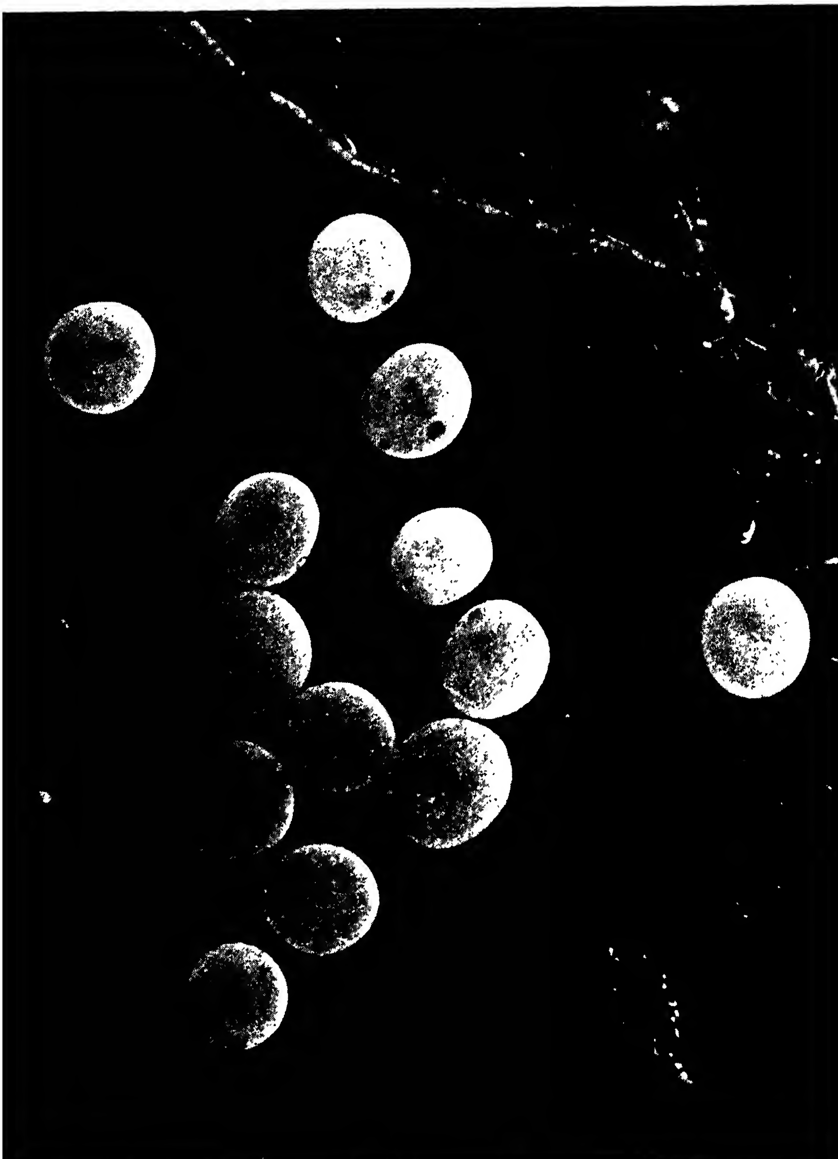
WHEN ALEVINS APPEAR

The hatching date cannot be definite to a day or two in any hatchery. It depends mainly on the temperature. At fifty degrees Fahrenheit, the eggs will hatch out in fifty days; each degree colder takes five days longer and each degree warmer five days less. This is generally known as Seth Green's law and has been in practice for at least one hundred years. The best temperature for hatching is between forty-five and fifty-three degrees. Fish hatched at a temperature of forty-five degrees, taking from seventy to seventy-five days are, according to hatchery experts, stronger and longer lived than those hatched in a shorter period.

Information from records of ten years at an English trout hatchery will be found valuable to trout farmers. The figures are for spring water at a constant temperature of 48 degrees Fahrenheit:



16. Trout ova with alevins emerging



17. Trout ova just 'eyed'

Rainbows (Shasta type) to eyed-stage, 21 days; hatching, 35 days.

Brown trout (*S. fario*) to eyed-stage, 22 to 26 days; hatching, 40 to 42 days.

In outdoor hatching brown trout one winter took 108 days to hatch. The hatching boxes were in a stream, the temperature was 33 degrees to 40 degrees and there was, for some time, a film of ice on the surface water and the hatching boxes.

Hatching goes on for several days. The shell splits and the alevin's tail end comes out. The tail, being the propeller, is used at once and shells can be seen being propelled this way and that, all over the trays. Sooner or later the shell falls away and the alevin is free and lies, for a while, on the bottom of the tray, exhausted by its struggle to get out of the shell. The trays must be cleared of the floating shells as soon as practicable. But if one cleans up too quickly many alevins may be destroyed. They are so tiny and may be still adhering to part of a shell. The covers on the trays should be removed only for the short periods necessary to take out empty shells morning and evening. The alevins, for a few days, prefer darkness. Their first instinct is to hide and they mass in the darkest corner like a swarm of bees. No food is given to them at this stage, for the large yolk-sac, attached to the stomach, attends to the nutrition. In a month or five weeks the contents of this sac will be used up and the empty case will disappear. The alevin is now a fish and will be searching for food. The trays can now be discarded, if not already done, and for a time the alevin's home is the trough. This should be now only partially darkened—having about one-third at the outlet end without cover. They will not grow, at this stage, in full light. They will stay in the bottom of the trough, with fins in constant motion. This motion assists in aerating the water. When they are ready to feed they rise from the bottom and stem the current with heads upstream. One must watch for this indication and immediately answer it with a supply of the most minute organisms from the natural food-bearing ponds or tanks. Alevins, like human infants, must be taught how to eat. If food offered is not minute the alevin may kill itself trying to swallow something too big for its tiny mouth.

MUD BATH FOR ALEVINS

Having fed them on natural food for two weeks or more the

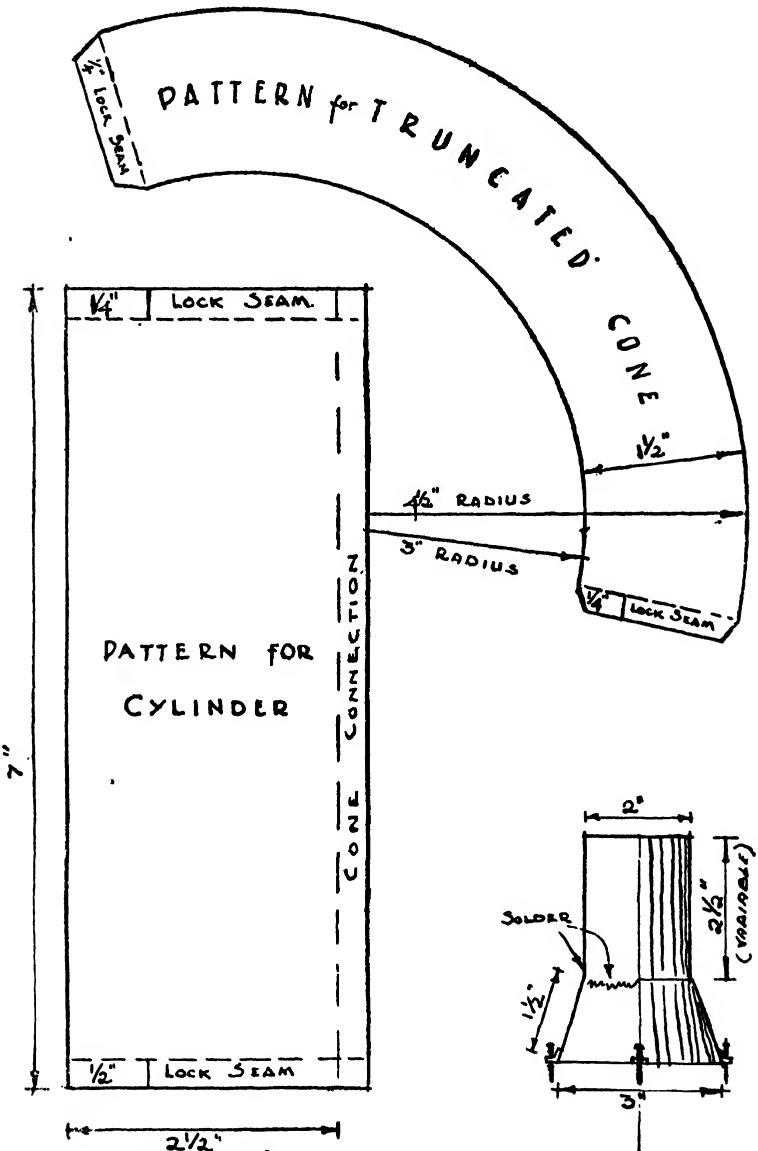
alevins should be given a mud bath. This can be done in several ways. Remember that earth only is wanted—not clay or gravel or peat. The better soils would be from a pasture or an old-established garden or even from a nearby ploughed field. Take some of this earth, sieve it and from the sieved soil make a mud paste. Place this on the sieve and shake it over the trough, going the whole length of the trough.

Another way is to place several sods or turves in a receptacle. Having broken them up as much as possible, add water and stir. Keep on adding water until you have a liquid mud which will pour. From a can pour some of this into each trough at the point where the water supply enters. The alevins, at first, will be frightened at the cloudy water, but when this settles and clears, they can be seen livelier than ever. The mud bath is a great tonic for them. It can be administered once, twice or three times a week.

The gravel from the filter tank can be removed at this time if desired, as the silt, should there be any, is now beneficial. Fine sand can also be scattered on the trough floors and around the edges of the outlet screens. After the first couple of weeks of the mud baths, in order to save labour, selected turves or sods can be placed on the apron of the water supply pipe in each trough. They will answer the purpose at this period. As a 'safety-first' move, a few handfuls of rock salt should be placed at the inlet of each trough and renewed from day to day, as required.

CLEANING THE TROUGHS

When alevins, and sometimes fry, are kept and fed in the troughs it is frequently necessary to cleanse the trough by draining. That is, taking out the plug at the bottom of the trough and allowing a certain amount of water to drain out with the debris and excreta, which is carried along the floor of the trough by the increased flow of water there. In the past this operation has generally been a difficult one because the rush of water has carried with it the alevins or the fry—very many of which get injured beyond survival or, despite the gauze screen over the hole, have escaped. To avoid such losses, hatchery men have succeeded in evolving a drain plug, now called the 'Cleaning Plug', which solves the problem. Such plugs can be


PATTERN for TRUNCATED CONE
¼" LOCK SEAM
1½"
RADIUS
3" RADIUS
¼" LOCK SEAM
¼" LOCK SEAM.
PATTERN FOR CYLINDER
CONE CONNECTION
7"
½" LOCK SEAM
2½" (VARIABLE)
2"
2½" (VARIABLE)
SOLDER
1½"
3"

quickly and easily made by following the diagram. It consists of a combination cylinder and truncated cone, made of sheet metal. Bottom diameter of truncated cone—three inches; diameter of cylinder—two inches. Larger diameters draw the water too quickly. Depth of water should first be determined and the cylinder height cut so that the water will be one inch over the top of it when placed over the drain hole. This allows the water to begin draining and gives a quick start to the waste in the upper end of the trough.

When the cylinder and truncated cone have been made, solder one end of the cylinder to the smaller diameter of the cone. Then solder four legs to the bottom of the cone to permit adjustment to the required height. Adjustable legs are made by soldering, to the sides of the cone, four lugs that have been tapped to take one-eighth of an inch full-thread electrician's bolts. The legs can then be adjusted to any desired height within their range.

In operation, the cleaning plug is placed over the drain-hole. At first the water will pass down the cylinder until the water is lowered to the top of the plug, then the remainder will pass under the plug. To regulate this the legs are adjusted to the required height. In this way only enough water need be drained off to remove the waste without drawing the fish on to the screen. The truncated cone is to permit quick placement of the plug over the drain-hole.

TROUGHS MADE OF ALUMINIUM

The latest idea in hatcheries is to make the troughs of aluminium instead of wood. This is now being extensively used in America. Aeroplane factories, apparently, have a large surplus of aluminium sheet, angle, channel, and extrusions. The troughs are exceptionally strong, do not sag or bulge, and the floor of the hatchery is dry as there are no leaks. The troughs weigh fifty-nine pounds, and the cost is less than that of wood. They are also easier to keep clean. The sides and bottom are made of twelve-gauge single sheets with one aluminium seam welded across the centre of the trough. The ends are welded into place. One-inch aluminium angle stick is riveted to overlap around the top of each trough. Overflow spouts ten inches wide and extending four inches are riveted and welded to the lower ends of the trough. The tail-screen channel slots three-quarters

of an inch wide and extending quarter-inch within the trough are made of moulded aluminium. A lead gasket is placed between the one-and-a-half-inch drain and a floor flange, which is riveted to the floor of each trough. The drains are pipe-fitted and stand-pipes are screwed into the flange to raise the water in the trough to the required depth.

It is a question whether to keep the fry, after they begin to eat, in the troughs at the hatchery or remove them to raceways. There is more labour involved in the trough method because the troughs must be cleaned at least once a day while a raceway needs attention only once a week.

CIRCULAR PONDS FOR FRY

The circular pond is growing much in favour, not so much for yearling or older trout but for fry. A circular pond fifteen feet in diameter, eighteen inches deep in the centre and receiving about ten gallons of water per minute will hold twenty thousand fry—but only fifteen thousand are advised because experiments have proved a quicker growth with the lesser number in the pond.

The construction of a circular pond is simple. A basin-shaped excavation is made with the bottom sloping gradually toward the centre. The most satisfactory sizes are between fifteen to twenty-five feet in diameter with a depth of from eight to ten inches at the margin and eighteen to twenty inches at the centre. It must be made of concrete because an earth pond would not keep the necessary slope for any length of time. The supply pipe should extend for some feet over the edge of the pond and should have several holes bored on one side of it, through which the water falls into the pond and thus cause greater oxygenation of the pond water. This allows for a larger number of fish to be put in the pond. The water flows out of the pond by an outlet pipe at the centre. It is here that the excrement and other wastes collect—hence the centre outlet.

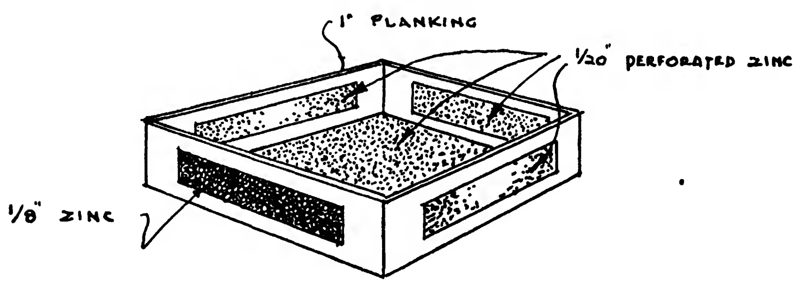
A self-cleaning device has been developed which automatically removes the wastes. This consists of a large sleeve which is attached to the outlet pipe and extends for a short distance above the surface of the water. At the bottom there is a narrow opening between the sleeve and a sloping flange which rests on the bottom of the pond.

The width of this opening can be adjusted according to the size of the fish in the pond. The wastes are drawn into the opening by the current of the water flowing through the outlet pipe.

Although one can propagate a considerable number of trout without a hatchery house, it entails much labour, most of it difficult. Ponds with a flow are required and several Pahari or Kashmir boxes. The boxes were invented for the original introduction into India of the British brown trout. They were so successful in the mountain streams of the Himalayas that English trout enthusiasts tried them out in streams and rivers in this country. They proved successful and many thousands of trout are hatched out annually by this means.

THE KASHMIR HATCHING BOX

The Pahari box is a simple affair. It is composed of a framework of wood with sides and bottom of perforated zinc two to three inches high. The top is a wooden lid, split in the middle and hinged at the sides. In the illustration the lid is not shown.



PAHARI BOX 1 FOOT SQUARE

The box is one foot square with one-eighth inch zinc on the upstream end and one-twentieth inch zinc on the downstream end, the sides and the bottom. Such a size will accommodate two thousand eggs. If a larger number of fish are to be propagated a more convenient size is two feet square with upstream zinc of three-sixteenths, downstream three-thirty-seconds, and sides and bottom three-sixty-fourths. This latter size is known as the Kashmir box. Stones and brushwood are piled on the lid. The box is put in position on bricks or legs, one and a quarter inches above the bed of the water

or at as near that height as possible to allow the water to flow just over the lid. The Kashmir box will take five thousand eggs. Eyed-ova are used.

The raceway or pond must be very shallow and should have a gravel bed. Canals or channels, bringing water to the ponds of a fish farm, could be used to contain the boxes instead of a separate and special pond.

CHAPTER XIII

FOOD AND FEEDING

Nutrition for humans, nutrition for animals, in a word—Food—is now and will be for some time to come, the number one priority subject for discussion both in print and talk. The aquiculturist and the agriculturist have alike the same problem, of how and with what to feed their stock, in order to bring it to marketable size and value in the shortest time and in the most economical way. The agriculturist cultivates his fields and the aquiculturist his ponds for natural foods. For artificial feeding the aquiculturist is at a disadvantage. He is debarred by controls from purchasing the ingredients which form the best of the artificial feeding-stuffs on which fish thrive; while the land farmer is allowed a certain, though moderate, scope.

Nevertheless, it is thought advisable to describe in detail the artificial feeding best suited to fish culture, as well as the cultivation of natural foods, because such knowledge will be useful when normality returns. Natural food is dealt with in the following Chapter XIV.

For many years, in all parts of the world, research stations and hatcheries have experimented with nutrition values of all kinds of artificial feeding for fish. The importance of the findings of such research lies in the facts, that every climate and environment, every water, each season of the year and every method of feeding at different ages, was utilized in the investigations.

Out of all this comes the result that meat, variously administered, is the prime basis for successful artificial feeding. Of these meats, beef liver and heart stand out as the best. These experiments are undoubtedly a benefit as a guide to trout fish farmers, for the statistics appertaining largely to the trout family, show clearly the paths to be followed. Figures of mortality are the important item—

figures of growth come second. Diets followed by high mortality were, after conclusive re-trial, discarded. Diets followed by low mortality and reasonably quick growth were recommended and are the diets now accepted by a majority of fish farms.

ARTIFICIAL FEEDING

Diets differ with the species of fish. In most countries, America especially, the investigations dealt mainly with trout and other game fish, on the continent of Europe with carp and goldfish and in China with carp, gold and other native fish.

These salient facts emerge:

That there is no universal artificial-feeding diet for all species of fish.

That artificial-feeding of fry is not advisable if natural food can be cultivated.

That artificial feeding, in ponds that are overcrowded and have poor water supply, is a waste of time, food, labour, and fish.

THREE GROUPS OF FOOD

Artificial feeding-stuffs can be divided into three groups:

Group 1. Fresh meats, including horse meat; liver, heart, lungs and spleen of cattle, sheep and pigs; fresh fish, both sea and fresh-water.

Group 2. Dried and ground products of animal origin, such as meat-meal, fish-meal, dried milk.

Group 3. Vegetable products, low grades of flour, wheat middlings, soya-bean meal, oatmeal, maize-meal.

Naturally the fish farms will use the cheapest possible ingredients, provided they give growth results. A number of combinations of the foods in the three groups have been made with varying degrees of success.

The dried products in Groups 2 and 3 have been combined and fed with results only fairly successful. This is also the case of products in Group 2 which have been fed without mixing. When any of the meals in Group 3 have been used, with Group 1 meat products as binders, the fish, as a rule, have picked out the meat and left the

cereals. Water should not be used in binding together a combination of products, it makes a mush which washes away quickly. Do the binding dry and always put in some common salt. Liver, if ground too finely, is apt to be wasted; it contains soluble constituents which are carried away before the fish can get to them. Beef liver, if not ground too fine, mixed with beef heart makes the best of all foods for artificial feeding. There is little, if any, waste and all the essential elements of a growth-making diet are therein contained.

A combination of pig liver with one of the cereals is a fair food. This liver when ground becomes very moist and sticky. As a binder of any cereal its stickiness is ideal because its juices are absorbed by the cereal. In combination with beef heart it is also a good growth-maker. Only moderately good results have been obtained with sheep liver and with other of the enumerated products in Group 1, not already specifically discussed.

Beef heart can, of course, be fed alone. This has been done, with the least mortality results, and the growth has been very good indeed. But there is a certain amount of waste, and considerable extra labour, in preparing this meat, because all the fatty and connecting tissues have first to be removed.

Meats must be fed in the raw state and must be fresh. Tainted meat would either not be eaten or would create disease in the fish.

Strange as it may seem, freshwater fish is not a good diet. Such fish, after being killed, decompose rapidly, and it may be that before they could reach a hatchery, be ground up and used as food, decomposition would have already set in. At any rate such food is unpalatable to fish at a hatchery and, therefore, a waste. Of sea fish the herring and the haddock are good food. They have to be ground up, bones and all. Salmon, so prolific on the Pacific coast, are used in hatcheries there.

MEATS AND MEALS

Regarding animal meals the best results have been obtained by American hatcheries with clam-meal. This is made from the discards of canning factories. Clams are not obtainable here, but mussels could be dried and made into a very similar meal. Most excellent results have been obtained with clam-meal mixed with any sort of meat. In fish-meals the best are pilchard, haddock and shrimp, in

that order. Pilchard, which is somewhat coarser and heavier than the others, has been the most successful. These meals are mixed with meat in the feeding. Shrimp bran is a coarse variety of this sort of meal, but it should not be fed to fish under five inches in length. It consists mainly of shrimp too small to use in the canning factories and contains a considerable percentage of essential minerals.

Some hatcheries use milk for their younger fish. Dried skim milk and dried buttermilk are the mediums. They are used with meat as a binder and growth and health results have been good. In fact the milk diet has quite a tonic effect on the fish. The skim milk is ground fine and, in consequence, there is considerable waste as it is soluble in water. The dried buttermilk is insoluble and is best used as a coarse-ground meal; there is little, if any, wastage. Fish, especially trout, eat milk products with avidity. It is known that anglers, the French in particular, use cheese as a bait with great success. It would be an advantage, if cost allows, to use the coarse dried buttermilk, both as a tonic and to make the food, with which it may be mixed, more palatable. Cereals, such as middlings, soya-bean meal, crushed beans, are not of use as food for trout. It does not appear that trout require raw starch. Even in a cooked state these cereals have not been found nutritious nor growth promoters. All fish, however, will eat bread with relish.

PREPARED FOOD IN TINS

There are several kinds of prepared foods in tins, in the form of biscuits or combined meals, which are manufactured for use as fish food. These were, no doubt, originally intended for those who kept aquariums and goldfish in globes or ponds. To use such prepared foods would be too costly for a fish farm where food is bought by the hundredweight or ton and not by the pound. The special biscuit, much used as a dog biscuit, is good and palatable food. It will keep for any length of time and a hundredweight stored at the hatchery might prove useful in an emergency.

There is no question but that the scientists have aided and do continue to aid the fish farmer. But many of their findings are not of practical help. Take the question of watercress, for instance. Theoretically, the feeding of greenstuffs should be beneficial to fish, as

it has been proved in relation to humans. Scientific research revealed that watercress should be an ideal food for fish because it contained all the very elements which the body structure of fish required. Watercress contains important amounts of calcium, phosphorus, small amounts of iron, copper, and manganese, and 2,520 units of vitamins A, B, C, and G. Attempts have been made over and over again to feed watercress, finely chopped, mixed with meat and other delectable substances. But the fish picked out the meat and left the cress. The same thing happened with carrots. Theoretically, eating the carrots would give trout enough carotine to improve the colour of their flesh. The carrots were ground fine and mixed with meat. The trout ate the meat but discarded the carrot.

Such attempts to vary or improve the diet of fish have been going on for a great many years. Some pond and hatchery fish do consume and thrive on occasional vegetable additions in their food but, in their artificial feeding menu, trout demand meat and no veg. The rudd is largely a vegetarian, while carp and the goldfish family consume fair amounts of boiled spinach, cooked cereals and chopped fresh lettuce. The grass carp (see chapter nine) is definitely a vegetarian, hence the name. It lives on grass, the leaves of shrub and trees, as well as on aquatic plants. The Chinese cultivate it, in conjunction with the common carp, in enormous quantities because of its very quick growth and the simplicity of its feeding. There is no reason why its cultivation in southern England should not succeed.

A cereal or other meal, with meat as the binder, is difficult to feed, with a uniformity of distribution, to the ponds. It is a sticky mass and using hands alone is a slow job. Using a spoon the food is distributed in chunks all along the length of a pond. The fish nibble at the chunks, and although they soon learn how to eat the mixed food, a great deal of the soluble matter is washed away before they can get to it. This is a waste. The system of feeding is a problem which, however, American hatcheries seem to be solving. They have many new systems. One of these is the use of a Ricer.

GRINDING AND MINCING THE FEED

The potato Ricer, a hand-operated mincing machine which cuts potatoes into tiny rice-like particles, is now used at many hatcheries

to grind down the bound diets to sizes suitable for feeding fish of varying ages. Such machines have a capacity of three-quarters of a pound of food and are proving useful in the feeding of small numbers of fish. With the addition of common salt, the bound diet forms a rubber-like mass; this, put through the Ricer, comes out easy to handle and distribute, either with the hands or a spoon. But American hatcheries, during certain seasons, have to feed very large numbers of fish, and there has now been constructed a pond Ricer, with a capacity of ten pounds of food and simple mechanical gadgets, which force the food through a perforated plate, the holes of which vary in size according to the age of the fish to be fed. This pond Ricer has two long handles with which it is lowered into the pond. The distribution of each ten pounds of food is done in less than two minutes. Hand feeding of the same quantity takes fully ten minutes.

Records, kept for six months, have proved the success of the pond Ricer. In hand-feeding it required nearly five pounds of food to produce a pound of fish, while with the Ricer only two and three-quarters pounds of the same food were required to produce one pound of fish. These results are considered due to the fact that the machine-fed fish had a greater amount of food available before any soluble components had time to wash away. The fish were given the same quantity of food as the hand-fed, but consumed it in one-third of the time taken by the hand-fed.

The following item of information is of no value to fish farmers except as a matter of interest. Biochemists have done a great deal of work over many years trying to give to hatchery fish the external colourings of wild fish of the same species. Out of the scores of chemical and food substances with which experiments were made only two emerge with real results. These are gulls' eggs, raw or cooked, and paprika. Brook trout produced the correct external colouration in about six weeks; brown trout, over a much longer period, became slightly coloured and rainbow trout showed no external coloration over a period of twenty-four weeks. From 2 to 10 per cent paprika was mixed with the regular food. There was no indication of toxicity. Cooked gulls' eggs, when fed by themselves, also produced some external colouration. The colour of the flesh of the trout remained unchanged in all of these experiments.

FEEDING DEVICES

But to revert to feeding devices, there is another mechanical feeding method used at mammoth hatcheries abroad. This is a compressed-air feeding machine which has become popular with hatchery attendants. By its use the labour of feeding vast quantities of fish has been reduced to a minimum. Three gallons of tightly bound food is placed on a perforated plate in a container. Compressed-air through a pipe is turned on and the food forced through the plate, emerging in worm-like shapes into the pond. The size of perforations varies with the age and size of the fish. The smallest perforation is $\frac{5}{64}$ inch.

Such elaborate machines are hardly needed in commercial fish hatcheries in this country. Although considerable time is occupied in walking around the ponds, feeding by hand is a simple business. The bound food is taken in a bucket to the pond and there distributed by throwing handfuls into the water as one walks the length of the pond. If the food be fairly dry, one's hand can be used, but if the food be a sticky mass—which is often the case—it is better to use a large spoon. This means that the food is dropped in chunks all along the pond at, say, six feet intervals, depending on the number of fish in the pond and the calculated amount of food allotted to them. It has been found by experience that such manner of feeding allows all the fish to get the food instead of only the larger ones. Feeding in chunks also avoids waste in the dry-meal supplement and the meat juices squeezed out in grinding. In using meal or other dry supplements, these should be weighed as, of course, should the meat.

While a higher percentage of meat is allowable, the percentage of the supplement should not be over 50 per cent. Some dried supplements are powerful and liable to burn up the fish if fed too generously and for too long a time. It is advisable for hatcheries to try out various cheap supplements before standardizing a mixture. They will want to decide which mixture helps the growth, keeps the fish healthy and is cheapest in cost and in labour. In feeding there are many things to be taken into account such as temperature, alkaline or acid water, pond vegetation plus or minus, season of the year, age, size and number of fish in each pond. Hatcheries know the answer to all these particulars and can act accordingly.

MONTHS IN WHICH TO FEED

Fish feed most from May to October. In June and July the natural food of all waters is at its maximum and very little artificial feeding is necessary. In winter fish appetites wane. It is a waste of food to give them anything like the spring and autumn quantities and only small portions should be offered and, if they do not eat it, then stop feeding, unless the weather turns warm and sunny. Winter feeding should be done about noon. Summer feeding in the afternoon. If ponds are frozen in winter and snow covers the ice, it is well to clear this off. It darkens the pond and the fish cannot feed on the natural food in the water because of this darkness. Fish feed more by sight than smell. While their sight is wonderful, it does not serve them in a pond darkened by the snow and ice. In addition to this clearance of snow, air-holes, of course, will be kept open in the ice.

In the feeding of carp and goldfish in still-water ponds, food trays are frequently used. These must be so weighted as to float just below the surface. The tray-feeding makes for more labour because each tray must be scrubbed clean daily, after use, and there is the work of putting in and taking out of the ponds. At the same time this method assists the fish farmer by indicating how much the fish will eat and how well they like different foods. The trays also help in preventing uneaten food from dropping to the pond bottom and there decomposing—always a source of trouble.

THE QUANTITY OF FOOD

The quantities of food to be given must be gauged by observation. No rule can be made because conditions differ. Two pounds of very finely ground food may be, in one locality, sufficient for five thousand fry, while the same amount coarsely ground may only just feed two hundred adults. Overfeeding is a snag the fish farmer must avoid. Sluggish, pot-bellied trout with enlarged livers, are of no use. It is better to underfeed than to overfeed.

When alevins emerge into fry and commence eating they may need to be fed—for a few days—as many as five or six times daily. As they grow this can be cut down until the bigger fry have a morning and afternoon feed only. Adults are fed only once a day. Depending

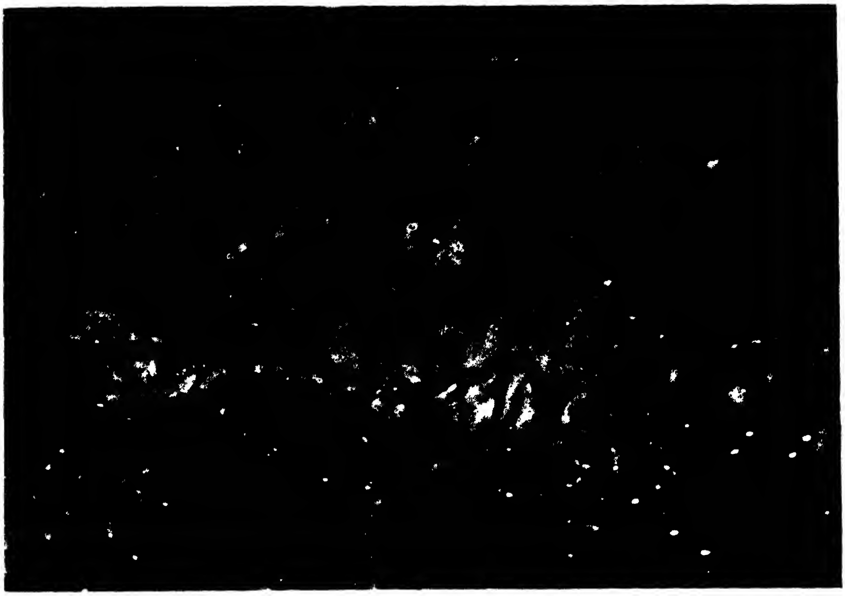
on weather and the other conditions, they are sometimes fed every other day, occasionally every third day. When fry are being fed several times a day, only a small portion of the day's ration allotted to them should be given on each occasion. Strict attention must be paid to this. The same rule holds good with fish fed morning and afternoon.

In preparing diets the dry meals can be mixed and stored ready for use. But the meals should only be added to the day's food two or three hours before feeding, in fact just long enough for the dry meals to absorb the juices. At some hatcheries the completed mixture has been stored for twenty-four hours—sometimes in a refrigerator—but this is not advisable. Scientists, particularly in America, are constantly at work on the nutrition, and other problems with which the fish farmer is faced. The questions of supply and cost are the main line of enquiry, but there has to be taken into consideration the rate of growth and the rate of mortality from this or that type of diet. Results of the investigations at fishery research stations, recently made known, should be of much assistance to fish farms here, although the fish used on these experimental feedings were rainbow and brook trout. While nutrition requirements of various species of trout vary slightly, yet it has been proved that good results with one species give equally good results with other species. The brown-trout farmer, therefore, need not hesitate to use the food, if procurable, which has proved successful in the rearing of rainbow trout.

Fish, like other animals and also humans, require a diet which not only keeps them alive but gives them vigorous growth and vitality. This means that their food must contain proteins, carbohydrates, fats, minerals, and vitamins.

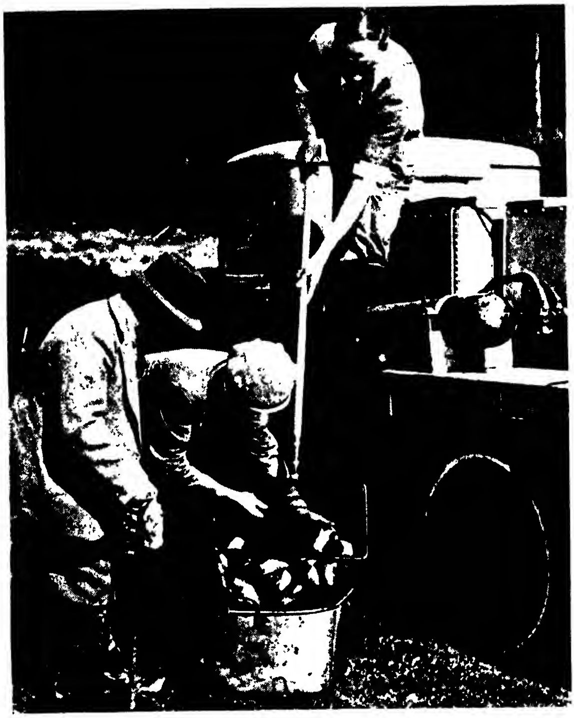
ROUGHAGE NOT REQUIRED

Some very definite pronouncements have emerged from the researchers. For instance, all offal from beef is superior to offal from pigs and sheep. Proteins take first place in food. Excess carbohydrates interfere with digestion, affect the liver and do not improve protein utilization. Fish, for quick growth, do not require roughage. They get enough of that in their natural food, although some fish culturists claim that roughage in artificial food is necessary. Roughage—



18. Young trout gathered at a feeding point

19. Netting a pond



20. Unloading fish at water's edge

21. Specially equipped lorry for conveying fish

says the latest experiments—tends to slower growth. The use of fish instead of meat in a diet means that twice as much fish is required to equal the growth produced by a meat diet. Most freshwater and frozen fish create a B_1 vitamin deficiency which leads to disease. Pike, perch or trout are freshwater fish which can be used or sea fish such as dogfish, cod, haddock, whiting. Fish should be fed separately and not in a mixture. Dry meals of animal origin can be fed without meat, but only if several are mixed together. A small percentage of cod-liver oil or yeast assists growth and provides necessary vitamins. A mixture of two parts fish-meal and one part each of meat-meal and dried buttermilk gave best results at lowest cost. When dry meals are fed to fry after they attain two inches in length, only ten to twenty per cent should be used in the mixture. As the fish grow this percentage should be gradually increased, and when they are five inches long as much as 70 per cent can be fed, although anything over 50 per cent means increased wastage. If fry, up to two inches in length, are being fed artificial food, it must be a meat diet without dry meal of any sort. Beef spleen should not be fed by itself. Some other meat should be included in a straight meat diet. In using only dry meals mixed as the food, it is advisable to have one fresh meat meal each week, which will lessen any ill-effects from the dry meal menu.

FOOD RESEARCH RESULTS

The table which follows consists of selected results from the feeding researches. Only the best are included. The list is compiled from a hundred different diets and gives some idea of the comparative values of different mixtures.

DIET MIXTURE *Figures are percentage of each ingredient*	*Increase in average weight* *per cent*	*Food to produce 1lb. of growth* *pounds*	*Mortality* *per cent*
Beef liver 70 Salmon-egg meal 30 (B)	2,027	2·06	4·2
Beef liver 70 Salmon-egg meal 30 (R)	1,239	3·29	1·6

Beef liver 60 Meat-meal 40	(R)	1,071	2·88	1·7
Sheep liver 58 White-fish meal 36 Kelp meal 3 Cod-liver oil 3	(B)	1,342	2·61	0·5
Sheep liver 58 White-fish meal 36 Kelp meal 3 Cod-liver oil 3	(R)	1,267	2·77	0
Sheep liver 60 White-fish meal 40	(R)	1,091	2·97	0
Sheep liver 48.5 White-fish meal 48.5 Cod-liver oil 3	(R)	1,153	2·74	0
Sheep liver 60 Dry mixture A 40	(R)	1,170	2·80	0·3
Sheep liver 58.2 Dry Mixture A 38·8 Cod-liver oil 3	(R)	1,337	2·63	0
Sheep liver 58 Dry mixture A 36 Kelp meal 3 Cod-liver oil 3	(R)	1,348	2·59	0
Sheep liver 25 Pork spleen 25 Cortland mixture 48 Salt 2	(R)	739	3·25	0
Sheep liver 50 Cortland mixture 48 Salt 2	(R)	739	3·26	0·3

(B—*Brook Trout* R—*Rainbow Trout*)

The dry mixture is composed of two parts of white-fish meal, one part meat-meal and one part dried buttermilk. The Cortland dry mixture is composed of one part each of white-fish meal, cottonseed-meal, middlings and dried skim milk. These dry mixtures can be purchased in bulk ready for use. Periods of the feeding trial varied from five to six months, different fry in different ponds being fed the different diets. The fish used in the experiments were fry of varying sizes and the conditions—environment, water, temperature, weather—similar to conditions in Britain.

SEA-FISH ARE GOOD FOOD

When food becomes more abundant it may be possible for trout farmers to adopt the methods of one of the most successful of English fish farms. After much research the artificial feeding was confined to two items: white sea-fish and lean animal flesh. Both were fed raw. Two-thirds fish and one-third flesh were the proportions in the weekly diet, but the white fish and the flesh were never both fed on the same day. The amount used daily was limited to 3 per cent of the weight of trout in the ponds. It was found that the weight increase of the trout was: on meat one-fifth of the weight and on fish one-eighth of the weight of the actual food consumed. Occasionally, when lean meat was not forthcoming, liver was substituted, and in that case a cereal was used to bind the liver. As a rule biscuit foods were avoided, and cereal used only as a binder, if circumstances so required. This feeding was for the larger trout. The fry were fed as long as possible on natural food. During very warm or sultry weather the amount of food given all trout was reduced.

WEIGHING FOR GROWTH

Weighing fish is somewhat of a problem, but the fish farmer will need to note the increases in weight in accordance with the various feeding methods and diets. One simple mode of securing an average weight is to get a bucket, half fill it from the pond water and then weigh it. With a dip net catch any ten fish and put them in the bucket and again weigh. The difference will be the total weight of the fish, which divided by the number of fish in the bucket will give the

average weight of individual fish. No doubt there will be a slight error on the whole, but it cannot be large enough to make much difference, and for purposes of calculation will serve very well.

CHAPTER XIV

FERTILIZING PONDS AND NATURAL FOOD

It behoves every fish farmer to set aside a number of ponds for the sole purpose of cultivating natural foods for both young and adult fish. Scientific research has been carefully studying the feeding of fish, their growth and health, and recent results go to prove that the successful fish farmer must use natural rather than artificial foods, especially for young fish. The question of where and how to get such natural food has been examined and the answer is: cultivate it.

There are two ways in which to feed the natural food to the fish. One is to place the fish in a fertilized pond for a period—say one month—and then remove them to another fertilized pond for the next month, and then back again to the first pond in which the depleted natural food has replenished itself.

The other plan is to lead the water from a fertilized pond by a ditch, canal or pipe to the fry and rearing ponds—or by dipping out the natural food from the fertilized pond and conveying it to the fish.

WATER FLEA IS PRINCIPAL FOOD

The amount of food required must be estimated by the fish farmer himself after a few days' experience. Ten to twelve pounds per day should suffice 20,000 fry; while 20,000 yearlings would require twenty to twenty-five pounds daily, as would 3,000 two-year-olds. *Daphnia pulex*, the water flea, is the principal food. One *Daphnia* female, through her progeny, reproduces thirteen thousand millions in sixty days. *Daphnia* are one-tenth of an inch in size when full grown.

The agriculturist, when his sheep have cropped one pasture moves

them on to another. The aquiculturist may well follow this example. In such case the fertilized ponds should be bunched together and be inter-communicating so that the young fish can be driven from one pond to another instead of being netted and handled.

There are many recorded instances at fish farms where fry have stayed in one fertilized pond until reaching the yearling stage, emerging as six-inch fish. During this period they were left to themselves entirely—a considerable saving in labour. In another instance two-year-olds, brought up only on natural food, surpassed in size and vigour the three-year-olds in adjoining ponds which had fed mainly on an artificial diet.

THE CRUSTACEA

The nutrition values of the different species of natural foods have not, as yet, been fully discovered, but most scientists agree, and the practical experience of fish farmers the world over, makes it positive, that crustacea are the best of all foods for young or adult fish.

The crustacea may be divided into two classes, scientifically known as Entomostraca and Malacostraca. The Entomostraca are very small, some being quite invisible, except under a microscope. *Daphnia* are the commonest form. Malacostraca are the larger crustaceans, such as *Asellus*, the water louse, and *Gammarus pulex*, the freshwater shrimp. The youngest of fish feed on *Daphnia* while the larger fish devour *Gammarus* and *Asellus*. There are hosts of other crustaceans of lesser importance with which one can become acquainted by reading books on natural history.

All living, and dead, organisms in water, play a part in the food of fish. The zoöplankton, of which crustaceans form the greater part, feed on the phyto-plankton and on the products of its decay and also on the other organic detritus to be found in water. On the bottom of ponds are worms, molluscs and insect larvae of all kinds, also feeding on the organic detritus of plant and animal origin.

Many methods have been tried, and many different methods are being used, in the culture of natural food for fish. One of them is to stock the ponds with *Daphnia, Gammarus* and other zoo- and phyto-plankton, netted from other waters. Another is by using chemical fertilizers, which has been fairly successful. But the most successful

has been the fertilizing with well-rotted animal manures and fresh, crude sewage. Domestic sewage, exposed to the air, becomes toxic. If used, it must enter the water in a fresh condition. Straw, whether fresh or mixed in the animal manure, should not be put in the pond. This fertilizing with manures and sewage has been the practice of Chinese fish culturists for thousands of years. Because of the great expansion of carp, goldfish and trout culture on the continent of Europe the fertilizing of ponds was introduced and developed rapidly, especially in the use of domestic sewage.

The natural food ponds should be of a small or medium-size and, unless trout are being propagated, need not have a flow. They should, if possible, have an earth bottom. In any event there must be at least six inches of earth, well-forked, on the bottom. Put in plenty of rooted plants. If horticultural fertilizers are to be used, sprinkle them on the pond floor.

CHEMICAL FERTILIZERS

A good chemical fertilizer is a mixture of 12 per cent phosphate, 7 per cent nitrate, and 7 per cent potash, although in some circumstances it may be better to use less potash. A new research has been to treat ponds with phosphates and lime only—and not potash. It may be that the inflow of water contains a rich amount of potash, and this makes up for its disuse. It is well known that phosphate, without the aid of potash, will lose much of its soluble power. While the chemistry of the water and the soil are, perhaps, distinct branches of the science, yet much is known from researches in both, of the value of potash. It will, for instance, kill obnoxious plants such as the horsetail, and it is death to leeches, which are such a nuisance in ponds. On the other hand it helps the growth of much of the desirable flora. Phosphoric acid which, in natural running water, or in feed-water becomes practically non-existent—at least to any appreciable quantity—may be used on the pond bottom, but always on a minute scale. It is a helpful fertilizer for the cleaned-out, dry pond and can be given as superphosphate or bone-meal. The question of the value of phosphoric acid is still being debated among fish culturists and research workers on fertilization. Material with a high nitrogen content is favoured by many.

Fertilizing Ponds and Natural Food

NATURAL MANURES

In using natural manures make a few small heaps on the pond bottom, here and there, a generous forkful to each heap. Liquid sewage, if it is being used, should then be emptied in. The water must now be turned on and the pond filled. If the pond has a flow, care must be taken at the outlet and a special fine gauze screen added because of the many minute organisms, whose escape with the flow from the pond must be prevented.

The manuring, or use of fertilizers, is unnecessary if zoo- and phyto-plankton are netted from other waters and introduced into a pond. In this case, the water in the pond should first be inoculated by a few gallons of water from some stagnant pond or pool, including some of the green scum always to be found on stagnant water. Then put in the netted plankton, and leave nature to do the rest.

Daphnia and many other species of Entomostraca feed mainly on the small green algae and diatoms and on decayed animal and vegetable matter. They are quite useful as scavengers because of their numbers. In size they vary from sixteen-hundredths of an inch to one-tenth of an inch. Direct and intense light hastens the life processes of a majority, but one lesser group prefers shade and dark places, and another lesser group lives around the slime at the bottom of the water. Spring, summer or winter makes little difference, except that the greatest abundance is in summer. The only things crustacea do not seem to like are spring water or flowing water. Their eggs have a remarkable vitality. If a fertilized pond is frozen over in winter one can take mud from the pond, place in a warm spot and soon have a plentiful yield of Entomostraca. Dried mud from Jerusalem, Australia, and China, some of it twenty-four to thirty years old, has been sent to England and the eggs hatched out.

Gammarus and *Asellus* feed on any soft green plants, especially watercress. They congregate where vegetation is thickest. They also eat decayed animal and vegetable matter and the smaller zoo-plankton. There are many forms, in size from one-twelfth of an inch to three-quarters of an inch. They are all good scavengers. It is an advantage, being food for trout, that these species flourish in the cold water so necessary to trout. A majority of the Entomostraca, on the other hand, seem to prefer a warmer water.

As in the culture of fish, the successful culture of natural food is conditioned by environment. The amount of light, the variations in temperatures of air and water, the weather, the nature of the pond bottom, the presence or absence of algae, the composition of still water or rate of flow, all have their effects in one way or another.

If the ponds devoted to this culture are made as close to nature as possible in all their conditions, it is certain that crustaceans can be raised in quantities. If there are objections to an exclusive crustacean diet for the fish, the objection is negatived by nature, the fish farmer can be assured that the reproduction of other animal life will not allow it to happen. A mixed diet is assured. The culturist may pay special attention to propagating the crustaceans required for the different sized fish, nevertheless the pond will yield many other forms of natural food whether the culturist wills it or not.

THE MAGIC OF RED CLOVER

An abundance of natural food can be secured in several other ways. There is, for instance, the magic of red clover. This can be developed in two ways. First, manure lightly an empty pond with well-rotted cow or other animal manure, into some six to eight inches of well-forked earth. Sow this fairly thickly with red clover seed. When the clover has grown enough to make a nice green carpet, turn on the water and fill the pond. Very soon the water will become grey with minute zoo- and phyto-phankton. As the days pass the water will resemble liquid porridge. Take out bucketfuls of this natural food and feed it to the fish ponds. A few buckets of this in the fertilizing ponds will also save the labour of netting Entomostraca to start them working. Secondly, if there is no empty pond available, the red clover seed can be sown on a prepared patch of well-rolled ground. When the clover is ready it can be cut into turves with a turf cutter and the turves positioned on the bottom of a pond. At first, it may seem difficult to carpet the floor of a pond, full of water, with these turves, but one soon gets the knack.

SOYA-BEAN MEAL

There is again another method of procuring natural food and

quite an easy one. After two years of research into all manner of substances that might produce water animal organisms, it was found that soya-bean meal and cotton-seed meal were the best. Both these meals are used separately, but in each case the meal is mixed with a small quantity of dried sheep or horse manure. They produce 25 per cent plus more organisms than animal manures or chemical fertilizers. The cotton-seed meal, however, causes the disappearance of phyto-plankton. The mixture is spread, at the water's edge, along the banks of the pond. It works better if the banks are of earth rather than bare cement. This method again eliminates the placing of manures, animal, chemical, or sewage in the ponds.

There is a method of cultivating Infusoria, the microscopic natural food that alevins receive on shedding their yolk-sac. Infusoria can be produced in quantity with some simple chemical aid. The method here given was evolved in the laboratory and is, therefore, on a small scale and in the metric measure. For practical purposes the amounts mentioned should be multiplied to the quantity required and translated into the English equivalents. One cubic centimetre of water (c.c.) equals 1 gramme (gm) and 100 gms equals 3·5 ozs.; 1,000 c.c. equals 1 litre and 10 litres equal 2·2 gallons. Here is the recipe:

Five hundred grammes of dry garden soil are boiled with one litre of water. This is filtered and to 50 c.c. of the filtrate is added 0·1 gm of Sodium Nitrate and 0·2 gms of Sodium Phosphate. This is used in the proportion of one part to twenty parts of ordinary pond water.

TO BRING WATER TO NEUTRAL

If a pond is acid the value of organic or inorganic fertilizers will be much lessened. Fertilizing should be done when the pond water is neutral or on the alkaline side. To get an acid water to the right condition an application of lime should be made. Acidity and alkalinity are expressed by the chemical term pH. A water can be quickly measured for its pH by the use of a Universal Indicator and chart to be had from any chemist. Neutral water is registered as pH 7. Anything under 7 is acid and over 7 is alkaline. Here are the quantities of lime (Calcium Carbonate) required to bring acid water to the neutral point:

To bring Water to Neutral

pH		*Cwts per acre*
4 – 4·5	..	24 – 48
4·5 – 5·0	..	18 – 36
5·0 – 5.5	..	15 – 24
5·5 – 6·0	..	8 – 15
6·0 – 6·5	..	7 – 8

Spring is the time to begin to apply fertilizers. For a new pond, applications for the first month should be two or three times a week. After that—and also for existing ponds—applications should be once a month, until early autumn, when the last application is given.

Organic and inorganic fertilizers can be mixed. There are so many conditions involved that one can only gauge the quantity to use per acre from experience and the results obtained. Inorganic fertilizer quantities can be more accurately estimated than the organic.

Here is an inorganic formula of which a well-mixed 500 lbs. (five hundred pounds) per acre per annum are used most successfully:

40 lb. Sulphate of ammonia.
60 lb. Superphosphate (16 per cent).
5 lb. Muriate of potash.
15 lb. Lime (finely ground).

CHAPTER XV

AQUATIC PLANTS

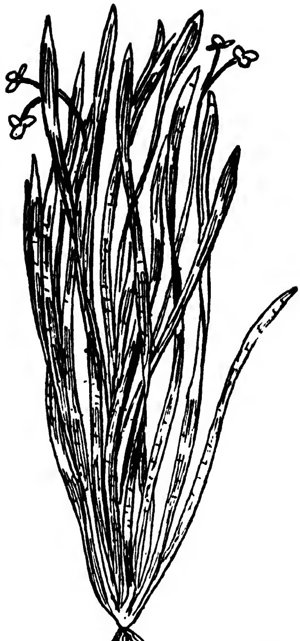
In pond-fish culture aquatic vegetation is a prime necessity. Algae are not only beneficial but absolutely essential.

Aquatic plants are divided into two groups—the minute plants, or Algae, and the higher plants, or Phanerogams. These latter are mostly flowering plants. Much of the algae is so minute that it cannot be seen by the naked eye until it has assembled as a mass and then the uninitiated decry it as pond scum or water slime. Algae can be found on the surface and under water. On the surface they become the food of tiny creatures who, in turn, are the food of small animals, and these again are food for larger still, until the big fish finish the cycle.

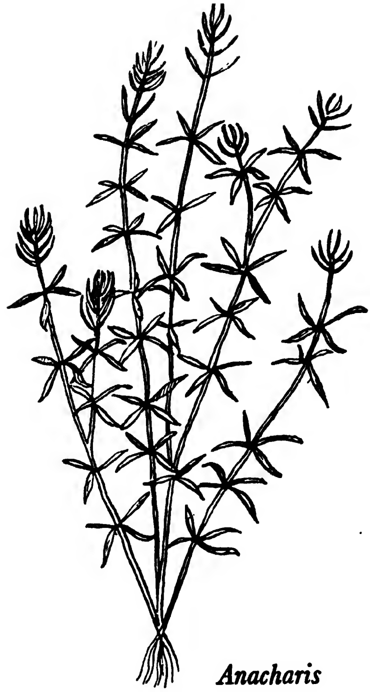
The higher plants are necessary because they provide the oxygen so essential to all living organisms; because they bind the bottom soil by their roots and thus tend to keep the water clear; because they collect fish food such as minute plants and animals on their roots, stems, and leaves; because they shade the fish from too bright sun and offer sanctuary to young fish from their enemies. Plants need light to live. It is rarely that a plant is found flourishing in deep water, because light does not penetrate below a certain depth. Photosynthesis is the name given to the action of plants in the light and darkness of day and night. In the daytime plants produce oxygen and give it to the water, where it becomes and is known as dissolved oxygen. At night time plants absorb oxygen instead of producing it and throw off the carbonic gas known as carbon dioxide.

THE RIGHT COMBINATION OF PLANTS

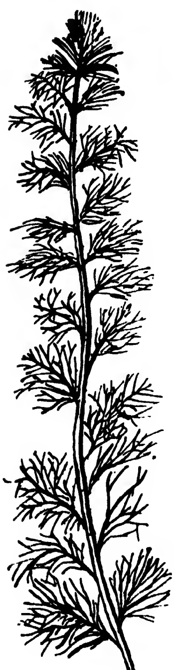
It is important to the fish farm to have the right combination of plants for the ponds—for trout, for carp, for goldfish. For garden



Sagittaria



Anacharis



Cabomba

Myriophyllum

ponds one needs emergent plants, but for the fish farm submerged plants are the more useful. Species of plants to be encouraged differ with the hydrosols. The character and depth of horizon A and also of horizon B must be considered.

There are more than one hundred water plants indigenous to Great Britain. Some will grow anywhere and under most conditions. Others need flowing water. Some thrive only in hard water, others only in soft water. A comprehensive list has been compiled. Only those aquatic plants of real use in the ponds and waters of fish farms, the ornamental or garden ponds and also water gardens have been included. It may be that water weeds, not here mentioned, suddenly appear in a pond or water, growing from seeds or fragments dropped by birds or carried by the wind. Such weeds are better destroyed as soon as recognized.

The list has been alphabetically arranged according to the Latin names given to the plants by botanists. This will enable those who wish to know more details of any of the plants to consult botanical works without any troublesome search. Some plants thrive best in chalk streams, others grow in most waters but have a slight preference for the calcareous. In the notes following, if no preference is mentioned, it can be accepted that each plant listed will grow in any water or boggy land. The submerged plants are the most useful in a pond because they are not only good oxygenators but provide an assembly place for pond food organisms. Marginals can be used in all the rearing ponds for shade purposes and because the roots help to keep the water clear. Some plants, ornamental, are for use in water gardens as are most of the marginals. All such facts are contained in the notes. Still-water plants are few. Most will flourish in flowing water. If no special mention is made, the plant is one suitable for ponds.

LIST OF AQUATIC PLANTS

Arranged alphabetically by their botanical names

Sweet Sedge or Flag (*Acorus calamus*). Long, slender foliage, very fragrant Marginal. (*A. gramnifolius*). Variety of Flag but leaves bordered with white.

List of Aquatic Plants

Water Plantain (*Alisma plantago*). Large spear-shaped leaves. Small mauve flowers on tall stalk. (*A. ranunculoides*) Smaller than above. Water garden or shallow water plant. Mauve flowers.

Floating Plantain (*Alisma natans*). Grass-like submerged foliage. White flowers.

Water Celery (*Apium nodiflorum*). Bright green submerged foliage. Shallow water and shade. (*A. inundatum*) Smaller species of above. Parsley-like smell. Tiny blossoms. Flowers above the surface.

Water Hawthorn (*Aponogeton distachyon*). Hawthorn blossom fragrance. Oval floating leaves. Large racemes of white flowers with black anthers.

Fern Weed (*Azolla caroliniana*). Floating. Separate frond-like leaves, deep green, turning to red in autumn.

Water Shield (*Brasenia peltata*). Bronze leaves and purple flowers. Water gardens and shallows.

Flowering Rush (*Butomus umbrellatus*). Long, narrow leaves with bright pink flowers. Water gardens and shallows.

Fanwort (*Cambomba caroliniana*). Originally brought from North Carolina, U.S.A. Also known as water shield. Is one of the leading aquatic plants, as it is the greatest oxygenator. Fine fan-like vivid green leaves which sometimes become brittle. Grows to several feet. One species (*croseafolio*) has reddish colouring on stems and undersides of leaves. Cannot survive in very cold water or in cold weather outdoors.

Water Arum (*Calla palustris*). Flowers like miniature arum lilies with delicate foliage. Water gardens and shallows.

Starwort (*Callitriche*). Submerged or partly floating. Vivid green colouring. Ornamental star-shaped tips on foliage.

King Cup (*Caltha palustris*). Heart-shaped leaves and golden single flowers. Should be planted in clumps in water garden or shallows. Needs mud. Another species (*C. plena*) has double flowers and blooms earliest of all. (Avoid former in fish ponds.)

Lady's Smock (*Cardamine pratensis plena*). Double pink flowers. Water gardens and shallows.

Tasselled Sedge (*Carex pendula*). Tall growing with large tassel-like flowers. Marginal.

Hornwort (*Ceratophyllum demersum*). No roots. Floats, but can be anchored. Dark green foliage in tufts submerged. Good oxygena-

tor. In winter sinks to bottom, but each tuft will produce new plant in spring.

Stonewort (*Chara*). Non-flowering. Still calcareous water only. Very useful in ponds. Good oxygenator and much beloved by insects. Another species (*nitella*). Soft-water plant. Very delicate thread-like leaves.

Water Thyme (*Elodea canadensis*). This Canadian water weed is a great oxygenator. Care must be taken to control it. It has a very vigorous growth. Also known as (*Anacharis*). Another species (*E. crispa*, or the Giant Anacharis). More bushy and dense growing. Especially good in a pool in winter, but must be strictly controlled. A wonderful oxygenator.

Rosebay (*Epilobium angustifolia*). Two to five feet in height. Large racemes of rose-coloured flowers. Water garden and marginals. Another species (*hirsutum*—Willow Herb) has large flowers bunched together in a terminal head.

Water Grass (*Glyceria aquatica*). Marginal for calcareous water. Light green soft leaves and green flowers. Another species (*G. fluitans*) is a floating meadow-grass, smaller than above. Can be used as a marginal submerged.

Mare's Tail (*Hippuris vulgaris*). Submerged and good aerator in winter and early spring. Later it rises above the surface and resemblance to mare's tail is marked. Shallow or deep water.

Water Violet (*Hottonia palustris*). Fern-like with rosettes of emerald green leaves. Submerged during winter. Spikes of mauve flowers in spring. Quick grower. Ornamental.

Frogbit (*Hydrocharis morsus-ranae*). Floating plant with much resemblance in leaves to miniature water-lily. Fine three-petalled white flowers. Long, trailing roots. Propagates itself by runners. Ornamental.

Yellow Iris or Flag (*Iris pseudacorus*). Water garden and marginal. Should be planted in clumps. Ornamental.

Corkscrew Rush (*Juncus spiralis*). Grows in corkscrew shape instead of straight. Another species (*bulbosus*) has a reddish-green colour and is amphibious. Has black flowers when grown out of water.

Duckweed (*Lemna*). Little green leaves that float independently on the surface. Indicate abundance of food matter in the pond. Ornamental and useful. Another species (*L. triscula*) is ivy-leafed. Often

entirely submerged. Of more value than the common duckweed.

Water Snowdrop (*Limnanthemum indicum* and *nymphoides*). Floating-leaved plant with many star-like white flowers, five-petalled. Leaves resemble water-lily. Ornamental.

Water Poppy (*Limnocharis humboldti*). Floating leaves and three-petalled yellow flowers with brown eye in centre. In strong sun grows and blooms rapidly. Ornamental.

Lobelia (*Lobelia dortmanni*). Small submerged plant with stiff, strap-shaped bright green leaves which form underwater rosettes. Blooms in late summer with small blue flowers on a long stalk.

Moneywort (*Lysimachia nummularia*). Marginal. Partly submerged. Many yellow flowers. Derives name from round leaves. Also known as Creeping Jenny and Wandering Jew.

Purple Loosestrife (*Lythrum salicaria*). Marginal and water garden. Numerous spikes of rich purple flowers. Another species (*L. vulgaris*—orange loosestrife) grows two feet in height. Large panicle of cup-shaped yellow flowers. Ornamental.

Loosestrife (*Ludwegia*). Water garden and marginal. Ornamental. In strong sun large oval leaves become brilliant red on underside. Another species from South America (*Isnardia palustris*) has been cultivated and is very decorative in water gardens.

Water Mint (*Mentha sylvestrix*). Has the scent and flavour of garden mint. Useful in keeping water in pond clear. Can be kept submerged by cutting back emergent stems.

Bog Bean (*Menyanthes trifoliata*). Large clover-like, out-of-water leaves with spikes of pinkish-white flowers. Large roots. Marginal. Useful in consolidation.

Monkey Musk (*Mimulus guttatus*). Rounded leaves with showy yellow flowers. Marginal. Another species (*cardinalis*) has a profusion of showy scarlet or crimson flowers. Marginal.

Water Forget-me-not (*Myosotis palustris*). Water gardens and marginal. Lower leaves can grow submerged but amphibious. Blooms from early June. Rough, stemless, alternate leaves. Favourite plant for newts who deposit their eggs on the leaves.

Milfoil (*Myriophyllum spicatum*). The ideal spawn receiver in the goldfish pond. Finely divided hair-like leaves and reddish stem. Moderately calcareous water. Other species (*M. alterniflorum* and *M. verticillatum*) prefer soft water. *Myriophyllum* is of special value in

ponds during winter and spring, when it is at its best. Swarms of smaller aquatic insects and larvae make it their home. Under certain conditions the blue-green foliage turns a bright red. A submerged plant, occasionally partly surfaced. Some of the various species grow longer leaves with a closer or more dense habit. These are the better for ponds.

Watercress (*Nasturtium officinale*). Chalk-loving plant, the chief habitat of the freshwater shrimp (*Gammarus pulex*). Needs shallow water and a flow, however slight. Admirable for small streams, rivulets or ditches. Another species (*N. amphibium*) is yellow cress. Marginal, in hard or soft waters.

Dropwort (*Oenanthe fluviatilis*). Calcareous water. Parsnip family, with bright green carrot-like foliage. Useful in winter and spring as submerged. Later produces large flowering stems which emerge above the surface and, perhaps, need controlling.

Gold Club (*Orontium aquaticum*). Shallow water garden. Many spikes of golden flowers. Leaves, under water, look like silver.

Virginia Arum (*Peltandra virginica*). Marginal and water garden. About one foot high. Arrow-shaped leaves and spathe-like flowers. Ornamental. An American importation.

Pickerel Weed (*Pontederia cordata*). Marginal and water garden, about eighteen inches. Pickerel-shaped leaves, blue flowers. Ornamental.

Curled Pondweed (*Potamogeton crispus*). This is the best of the very large family of *Potamogetons*. Its leaves are long with parallel sides and a wavy edge with fine teeth. At first the leaves are a transparent green with a glossy finish. Later in the season the leaves turn to a rich reddish-brown. Submerged. Calcareous water. The *Potamogeton* family can be divided into three groups: grass-leaved, broad-leaved, and hair-leaved. Most of them die down in winter, but a few continue the year round and flourish. Control is very necessary. They are good oxygenators and useful in ponds. *P. densus* and *P. natans* are two well-known varieties of the many growing in the British Isles.

Water Crowfoot (*Ranunculus aquatilis*). Hardy winter plant for ponds. Submerged. Bright green foliage, very hair-like. Produces profusion of white flowers in spring. Another species (*R. hederaceus*) has abundant kidney-shaped leaves, light green and floating. Small white flowers. Marginal.

List of Aquatic Plants

Spearwort (*Ranunculus lingua*). Marginal. Spear-like leaves with large, glossy yellow flowers. About two feet in height. In ponds will grow submerged foliage and is good aerator. Also water garden ornamental plant.

Water Buttercup (*Ranunculus fluitans*). Some have wide, floating leaves, others have finely divided hair-like leaves. All have showy white flowers. Water garden or shallows. Ornamental.

Crystalwort (*Riccia fluitans*). A vivid green moss-like plant that floats in a mass just beneath the surface. Very valuable as an oxygenator. Likes sun. Is refuge for tiny, newly-hatched fish and insects.

Arrowhead (*Sagittaria*). This plant is useful in ponds, as marginals or in water gardens. It takes its name from the sign of the Archer in the Zodiac because of its arrow-shaped leaves. There are several varieties. *S. chinensis* is submerged with very long leaves like one-inch wide ribbons. *S. japonica* is very ornamental with erect, glossy arrow-shaped leaves and a large spike of white flowers with golden centres. Some have large double flowers. *S. natans*, known as the Ribbon Arrowhead, is the best of the family for ponds. Average height is around one foot. It is a splendid oxygenator and grows throughout the year, multiplying slowly from runners. The roots are few and short, but help to purify the soil and keep the water clear.

Lizard's Tail (*Saurus cernuus*). Marginal. White flowers.

True Bulrush (*Scirpus lacustris*). Grows to six feet. Erect, round stem with brown flowers. Under water produces masses of narrow dark green ribbon-like leaves. Marginal. *S. zebrinus* is an ornamental variegated species.

Water Parsnip (*Sium erectum*). Very similar to water celery although *Sium* will grow in deeper water than *Apium*. Both like shallow water and shade. Attract organisms and, therefore, fish.

Bur-reed (*Sparganium ramosum*). Large-leaved erect plant with flowers in the shape of balls or burrs. Good for margins and water gardens.

Water Soldier (*Stratiotes aloides*). Grows either floating or attached to the bottom. Sword-like leaves with serrated edges. Often grow over a foot in diameter and float just below the surface. It turns from green to red during summer. White flowers.

Water Chestnut (*Trapa natans*). Pointed serrated leaves somewhat like those of chestnut tree. Makes a small, handsome rosette

with flowers in the centre. An annual, it seeds itself. A floating plant.

Bladderwort (*Utricularia vulgaris*). This unique plant is carnivorous, having numerous bladder traps in which it catches the microscopic forms of animals in the water and extracts their juices. Because of this they should not be planted in the first of the fry ponds. Foliage resembles *Myriophyllum*. Submerged. Still water only.

Speedwell (*Veronica beccabunga*). Oval, glossy leaves and tiny vivid blue flowers. Marginal and water garden. Ornamental.

Tape Grass (*Vallisneria gigantea*). has long, narrow, tape-like leaves, sometimes six feet in length. Best of all oxygenators. Rooted, leaves floating and submerged. Dies down in winter. Propagation by runner or seed. Separate male and female plants, females predominating. Small, white, cup-shaped female flower floats at end of long spiral on surface. On separate plant male flower, like a small ball, containing pollen, grows near the root. When ripe the flower ball bursts and the pollen floats to the surface, where fertilization takes place, with the help of wind or flow or insects. In runner propagation male or female plants only produce their own sex plants.

Horned Pondweed (*Zannichellia*). Hair-leaved pondweed. Submerged. Light green leaves and flowers within the leaves. Good oxygenator.

In selecting plants for ponds one must, as already stated, consider the composition of the water. Before securing plants it is advisable to visit waters in the immediate locality and observe those aquatic plants which seem at home in flourishing condition. This will make selection both easier and safer. Garden and ornamental ponds should have attention in spring and autumn, especially in the latter season, when certain emergent plants, dying down, may be removed and others, particularly submerged plants, be put in the pond. In the dark days of winter the pool will thus continue to remain a spot of beauty.

REMOVE DECAYING PLANTS

It is in November that most of the emergent aquatic plants die away not to appear again until May. The decaying remains drop to the bottom of the pond and decompose. While shrimp (*Gammarus*)

will feed on the decayed remains, they will not clear it all up. Therefore, it is best to remove the plant and avoid toxicity.

Flowering and rooted plants get their sustenance not from the water as popularly supposed, but from organic matter, such as silt, in the bottom of the pond.

Instructions on how to plant in a pond are necessary. One must not accept aquatics in rivers as examples and just dump the rooted plant into the pond hoping for the best. In a river the current is continually breaking up plants, pieces of which float along until reaching some little backwater or silt patch. There they stop and, in most instances, are soon growing into new clumps.

In garden pools and ornamental ponds plants are frequently grown in pots placed on the bottom. For small ponds this often proves a very useful way, especially by giving complete and easy control.

Planting can be done at any time of the year. Emergent flowering plants will produce blossoms the same year if planted from February onwards. Those planted in summer or autumn will flower the following spring.

HOW TO PLANT

To start planting in a pond, first of all have only six inches of water in the pond. Cut a sod of turf, turn it upside down and place it in the position desired in the pond bottom. Spread out the roots of the Emergent (or partly emergent) on it and cover with well-washed but coarse sand. Do not use fine sea or other sand because it clogs or packs too tightly. If you do not use an inverted sod of turf, a shovelful of earth dug from a nearby ditch or stream will do. The sand should just cover the roots and the earth—the crown, from which the leaves emerge, should not be covered. It may take some time to plant the whole pond and more time to fill it with water. During this period the aquatic must not be allowed to get dry. Watering from a can, through a rose, is the solution. In letting water into the newly planted pond, unless it be a very gentle flow, use a temporary apron rather than direct on to the pond bottom.

Submerged and floating plants, which are the most important in the fish pond, can be planted at the same time as the partly emergents or left until the pond has been filled to its proper level. They should

in any case be weighted with a stone to keep them in position on their introduction into the pond. They will soon lose the weights and establish their proper position.

The water, for a day or two, may be somewhat cloudy. Allow the plants a week to themselves before introducing fish.

WATER LILY AND LOTUS

Water lilies (*Nymphaea*) are considered with the Lotus (*Nelumbiums*) as the most beautiful of all aquatics. They are not of interest to the fish farmer unless a show pond of goldfish is established on the farm. The lily is the best plant of all for goldfish in a garden pool or ornamental pond. It provides the fish with food, shade and security. The hardy lily can remain in the pond the year round. It is not affected by a severe winter. Lilies should be planted in April or May and they will bloom from May to October. They demand rich soil, so it is necessary to mix loam or clay with well-rotted manure. Use a box, say one foot deep by two feet six inches square, fill this with the mixture and plant the lily in it, but do not cover the crown. A bag made of matting, such as a fish bag, or a wicker receptacle, is even better than a box, if they are procurable. Water lilies can be planted in water from one to three feet in depth. The crown should be from eight to twenty inches below the surface. They do not root deeply, but expand in diameter. Every three years they should be raised and the many crowns they have grown cut off and planted—but only one crown in each box, bag or basket.

The Lotus, a really magnificent plant, requires a big pond. It roots deeply—sometimes more than three feet—and winters well in the open pond and grows amazingly.

There are several types of water lily. The pygmy is a Chinese plant suitable for very small pools or in basins or tubs in a water garden. One variety is yellow with marble leaves; another is pure white.

Then there are the tender varieties which have to be taken up every autumn—the tubers on the main root are broken off and dried and then planted out in the following spring. The tender lilies are of two kinds, the day blooming and the night blooming.

Of the hardy lilies there are two varieties which are deliciously fragrant. These are the white *Caroliniana* and the salmon *Caroliniana*.

Some of the varieties of the Tuberosa and Odorata sections also have a fragrance, but the main family of water lilies is scentless.

Different coloured hardy Lilies are named as follows:

Nymphaea Alba—white.

N. Gladstoniana—white.

Tuberosa richardsoni—pure white.

N. Paul Hariot—pink inner petals, copper outer petals, golden anthers.

N. rosea—rose colour with orange stamens.

N. aurora—rose, orange, and deep red.

N. comanche—copper streaked with red. Olive green leaves flaked with brown.

N. chromatella—canary with orange stamens, marbled leaves.

N. Ellisiana—vivid red, orange stamens.

N. Sirius—deep red, bright red stamens, dark green leaves spotted with brown.

Tuberosa rubra—carmine, deep orange stamens.

Plants to avoid in ponds may be quite numerous. The undesirables are not listed. A word of caution, however, may interest pond owners. Of plants often used in or around ponds are two which should be avoided. They are the common wild yellow water lily (*Nuphar lutea*) and the Marsh Marigold. If there are no fish in the pond the plants can be permitted, for it is on account of the life in the pond that avoidance is recommended. This is due to the fact that *Nuphar* has some repellent odour attached to it. The minute plankton and insects generally keep away from it. The fish, therefore, find no food on these plants nor the security which is attached to the large, stately leaves of the cultivated water lily.

Regarding the marigolds (*Caltha palustris*), a bog plant used attractively as a marginal on the banks of ornamental ponds, it has proved to be dangerous to fish in some instances—fortunately rare. Some of these plants burst their seed pods and the barbed seeds scatter like miniature shrapnel. Fish, feeding among the plants, have been killed by these barbed seeds.

ALGAE AND WATER BLOOM

To turn to another form of water plant-life—Algae, the minutest

of all. In fish production the algae are not only beneficial but absolutely essential. While seldom used directly by fish, they are fundamental in the process of fish food production because they transform the elements into useful substances. They are the food of the fish-food organisms and thus are an important link in the food chain. Rainfall and temperature as well as environment have much to do with algae growth. With a high temperature and a high rainfall the 'water bloom' will cover ponds almost magically. The diatoms are the first to appear. They feed on certain dissolved substances in the water. When these are finished with, the diatoms die and blue-green algae appear. These may be the more common types, *Anabaena* or *Oscillatoria.* Blue-green is the name given to a group of minute plants in the plankton—consisting of minute animals and plants—in waters. It is not named for the colour only, because the blue-green algae can be yellowish-green, blue-green, brown or purple. There are eighteen hundred species which live either free-floating or attached to other plants. This group requires dissolved organic matter for their development. The organic matter is derived from the decomposition of animals and plants and also from the surrounding earth and washings therefrom. A strong growth of these algae proves that the water is very fertile in food substances. A heavy blanketing of the surface of the pond by blue-green algae may cause the fish to seek the bottom of the pond. It may be that their gills become clogged by the algae's fine filaments, but certainly the oxygen and carbon dioxide balance is upset in the upper layers.

The algae will colour the water. *Oscillatoria tenuis* will make it a vivid green and *O. bornati* a deep brown.

The fish, for several days, will take their meals from the tiny animal life to be found among the floating plant blanket. Then they will disappear, and this is the time to sweep up the algae. In ponds, unless they are large, this can be done with a rake, enveloped in a sack or with a long-handled net bag. Daphnia, snails and other scavengers in the pond will clean up the remnants, as algae to them are important food.

Should the 'water-bloom' not be swept up, it will, in due course, die down and disappear, leaving the water clean and clear.

Blanket weed, the bane of all waters, is formed by algae, by those with long threads. These entangle each other and form great mats.

They are known as *Cladophera*, *Vaucheria*, *Spirogyra*, and *Oedogonium*.

TO ERADICATE HEAVY GROWTH

To eradicate heavy growths of water weed, and especially algae, chemicals have been used. On fish farms with large ponds or lakes it may be necessary to use them, but chemicals on small ponds and in general should be avoided. Experience has proved the safe concentration of different chemicals to the volume of water to be treated. The chemicals are naturally lethal to fish and animal life in the water and, unless the quantities are used as laid down as the safety lines, the fish will be killed as well as the weeds.

Action of the chemicals differs in hard and soft waters and in the composition of the bottom mud. The outlet of the pond has also to be considered; it may be necessary to dam this up for several days, or again the pond may be emptied half-way before treatment, provided it needs two days at least to fill again to its proper level.

In distributing the chemical in a small pond, the solution can be made up in a water-can and then poured over the surface through a rose. In a large pond it can be towed in a sack from a boat until all is dissolved; or the solution sprayed on the surface from a hose or watering from a can through a rose—a supply tank of the solution being carried in the boat.

Waterworks engineers every year have to rid their great reservoirs of algae. Although these reservoirs are full of fish and the water companies derive an income from anglers, the engineers are concerned only with the killing any and all algae and thus clearing the water. They, therefore, sometimes use concentrations toxic to many fish. Different chemicals have been used in reservoirs. Copper sulphate, chlorine, and chloramime—the latter is a compound of chlorine and ammonia.

To destroy algae in ponds without affecting fish or pond life generally the following are the strengths of solutions:

Copper sulphate: one ounce to forty thousand gallons of water.

Potassium Permanganate: one part per hundred thousand parts of water.

Bleaching powder: two pounds per hundred thousand gallons of water.

THE USE OF ARSENIC

Sodium arsenite is now manufactured in England commercially for the control of weeds in ponds. Experiments were made, by direction of the U.S. Government, some fifteen years ago. They were so successful that the use of this toxic solution became an established factor in weed control throughout America. Some time later several waters in Hampshire and lakes in the north of England and Scotland were treated, under the auspices of the Fisheries department. Results were satisfactory and the use of sodium arsenite for weed control was adopted here.

There is little, if any, danger in the use of this arsenic solution—but bathing should not be allowed in the treated waters. The fatal dose for humans is from one to three grains, or thirty to sixty quarts of the water at its first treatment. Cattle and smaller animals have not been affected by drinking the treated water, but it is safer not to allow domestic animals to drink it for at least ten days.

The safest effective concentration is 1·7 parts of sodium arsenite per million parts of water. It is important to measure, as accurately as possible, the quantity of water in the pond. Multiply the length by the width; then multiply the result by the average depth. To convert to gallons multiply the total by 6¼. The solution must be evenly distributed over the entire surface of the water and high concentrations at any one spot must be avoided. The best plan is to spray the solution from a watering can with a fine rose, using a punt or boat containing a barrel or tank. Spraying from a hose is unpleasant, perhaps dangerous, to the operator if there should be any wind.

In twenty-four hours the concentration of sodium arsenite is reduced by 50 per cent; in ten days there is only a trace remaining. In a fortnight the water is normal.

Fish are unharmed by the treatment, as are planktons, insects, and other fish foods. Some species of algae are invigorated, other species decline. The dissolved oxygen in the water decreases at first while the carbon dioxide increases. But they soon regain their normality. It is most important, however, to gather up the weeds as they are killed, for the dead or dying vegetation in quantity has a bad effect.

Better results are found in alkaline waters.

If a big pond, a lake or large sheet of water is to be treated, the

spreading of the solution may occupy several days. In such cases the water should be divided into sections or squares, roughly outlined by temporary poles to give equal surface measurements to each square. This will ensure proper distribution and safeguard water from being treated twice or even left untreated. A sketch map of the water, with the squares marked, would be useful as a guide during the several days of treatment, each square, after treatment, being crossed out.

It is important that the treated weed should not be allowed to remain in the pond and rot, thus de-oxygenating the water. It should be taken right away, because if just dragged out on the banks, seeds or small broken pieces might be blown back into the water by the wind and the nuisance start all over again.

Destruction of overgrown weed beds can be accomplished by mechanical means. There are a number of devices on the market intended for use mainly on rivers, canals or very large lakes. These consist of motor boats equipped with cutting knives. There is also a punt equipped with a hay-mower knife and run by an Evinrude motor, which might be useful for a lake or ponds of a few acres in extent. Among hand devices is a weed-cutting saw operated from either bank. It is used on ponds. For small ponds, an ordinary scythe will do the cutting satisfactorily or the weeds can be dragged out with grapnel, prongs or rake. Such work should be done early in March and in the autumn. If done in summer it may cause such a de-oxygenation of the pond that the fish will suffer.

People who are constructing a pond or pool in the garden, and those who hope to delight in a water garden, and some, proposing to establish a fish farm, often ask how and where they can get the necessary water plants. In the wild waters of river, stream, lake or pond in the immediate neighbourhood one can gather enough wild stock to satisfy most needs. In gathering these, one should remember that various types of such wild plants grow in their own particular type of water. It is not advisable to take a plant from a calcareous stream and replant it in acid water. By identifying the various plants one can determine the type of water in which it naturally grows. If in doubt, refer to the list of aquatics given in this chapter. There should always be a near similarity in the water from which plants are taken and the water to which they are to be transferred.

If cultivated plants are wanted and they, of course, are desirable, one can secure most varieties from dealers, whose advertisements will be found in periodicals, weekly or monthly, devoted to fish or ponds or aquariums.

CHAPTER XVI

ENEMIES OF FISH

Every living thing is a potential victim of some aggressor. It may be thought that fish have more enemies than other animals, when one goes over the list. But this is due to the fact that more and closer studies have been made of the subject, in connection with freshwater fish, and we have more detailed information available. The careful fish farmer will not have to enter on his ledger many losses due to enemies preying on his stock. So much is, nowadays, known of predacious creatures, that prevention of attacks is, usually, possible.

So far as nursery ponds are concerned, if the fry are overcrowded, they offer temptations which are, now and again, accepted by stray domestic fowls, by rooks, crows, and cats. These cannot, however, be classed as more than occasional predators.

BIRD PREDATORS

Water birds generally are classed as preying on fish. Some, however, are quite innocent. The chief offenders are the kingfisher, whose deadly work is chiefly confined to fry and small yearlings; and herons, dangerous to adult trout. The heron will not only eat the fish till hunger is satisfied, but will also maim or kill others ruthlessly, for no known reason. Gulls, especially the black-headed ones, are attracted by a fish farm during bad weather, when they fly inland from the coast. Swans and ducks are devourers of ova and alevins and, in the spawning season, will clean up all the ova in a pond as it is being spawned. They are said to be vegetable feeders, and because of this, no doubt, erroneous advice has been given over and over again to complaining pond owners to use the domestic duck for the purpose of keeping down the too luxuriant weed growth.

This is not good advice on any count, for ducks will not only eat all accessible ova in the spring, but also, at other seasons, will devour much of the natural fish food in the pond.

Moorhens, dabchicks, and water-ousel do not eat fish ova. Dabchicks may eat small fry, as may moorhens, but only when other food is unavailable. Water-ousel—despite their classification by river-keepers as fish enemies—feed only on insects and are harmless to fish life. They are frequently seen at and around redds and other places where ova are deposited; these birds are really a benefit around waters, for they eat the insects which, attracted by the spawning, swarm around the ova.

The otter and the vole are on the list of enemies, but some writers on Natural History declare that otters do not eat ova nor do they eat fish of the Salmo family, instead they feed largely on the trout's great enemy, pike, and also frogs, water beetles and such like. However, the fish farmer should encourage neither otter nor vole. The otter is always liable to visit the ponds and frighten the fish by dashing through a succession of ponds followed by her young, to whom this extraordinary occurrence is, maybe, a lesson or a game. The vole is a nuisance and liable to bore holes in bank or wall of ponds or channels.

Land rats, which will, of course, be kept down on any fish farm, are particularly harmful in that trout ova attract them and they can soon upset a whole season's hatching, if they get into the hatchery house. They have been known to eat massed ova, too, in a pond. Such rats succeed in keeping under water for short periods.

FISH PREDATORS

Adult trout devour ova. There are records of father trout and several boon companions waiting beside a redd while the female was in the act of spawning, and as the eggs fell they ate them. In one remarkable instance several of the egg-eaters being quickly netted were found to be gorged with ova, which spilled from their mouths—much of it was collected, put in a trough, and in due time hatched out.

While trout are cannibals, they will also eat other species of fish. One of the worst things that can happen to a nursery pond is the

uninvited presence of a large fish. It is recorded that a two-year-old trout who jumped out of a can got into a fry pond and when, a year later, the pond was fished and emptied, over thirty-five thousand fry were missing. The jumper, now a three-year-old, weighed five pounds.

Pike, however, may be considered the worst fish of all fish-enemies. It will eat fish of almost any size. Eels and perch are also great fish-eaters, especially of fry. Lampreys eat alevins and small fry.

Frogs have been found dangerous, but only very occasionally, to adult, slow-moving fish such as carp, in that they have blinded many by clinging to their backs with forefeet fixed in the eye-sockets of their victims, who subsequently died. It is believed the frogs seized on the fish as a support in spawning in the water, as there was no vegetation in the ponds where these occurrences were noted. While frogs may eat some fish-food in a pond the principal item being water-beetles, they may be considered useful rather than inimical. Tadpoles, in their earliest stages, are eaten by the fish. They can usually be seen on the banks of a pond, in great numbers, basking in the sun and growing first their hind legs, then their front legs. Later the tail becomes stumpy and then disappears and a minute frog is revealed. Toads are also useful because they eat beetles in quantities.

Snakes, water or land, need not be considered as enemies, although they are classed as such by some, because when in the water they are frightened of the adult fish, who make valiant efforts to catch and eat them, causing much commotion in the water.

THE BEETLES THAT ARE DEADLY

The enemies of fish—the most deadly of all, which the fish farmer will soon realize—are beetles. But their deadliness extends only to young fish, fry principally, because yearlings can dodge attacks and when yearlings happen to be large for their age, they begin to feast on these beetles, as do their elders.

It is unnecessary, of course, for the fish farmer to become a systematic entomologist, but a study of the ecology of a pond should be undertaken. Every fish breeder working toward success should be able to identify the insect enemies and pests, and so act as to guard against or lessen their depredations. The descriptions which follow may help to familiarize some:

The Great Water-Beetle, one of the largest of the water-insects, known as *Dytiscus*, is the chief enemy, particularly the larva known as the water-tiger. They are voracious and a few score would soon depopulate a pond containing thousands of young fry. The species are cannibalistic and, if hungry, attack each other until only one, the victor, remains. The *Dytiscus* is rich brown in colour and very shiny. There is a yellow band edging round the thorax and wing case. The male has large round pads with suckers underneath on each of the front legs. The female is the same colour but is smaller in size and her wing cases are deeply ribbed or furrowed. The larva hatches out in three weeks and when grown is two inches long. It is pale brown in colour, broadest in the thoracic region and tapering to the tail. It has six legs. The head is large and furnished with a pair of curved, sharp, but hollow, jaws with which it clasps and pierces its prey, sucking its blood.

The Black Water-Beetle, known as *Hydrophilus*, is the largest of the water-beetles. It is often mistaken, at first glance, for *Dytiscus*, but is a vegetable feeder and therefore, harmless. Its larva, strange to say, is dangerous, being carnivorous during its youth. This black beetle moves very slowly, walking through the water. The female makes a cocoon for her fifty eggs, which is shaped like a boat and has a hollow mast rising above the surface of the water; this admits air to the eggs, which hatch out in six weeks. The beetles, black in colour, as the name implies, present a silvery appearance under water.

The Whirligig Beetle, known as *Gyrinus*, is shiny steel-blue in colour and a quarter of an inch long. The body is oval, round above and flat underneath. Its two eyes are divided into four to enable it to see above and below the water. Its usual station is on the surface where it is easily identified by its whirling round in circles and curves. The adult, as well as the larva, is carnivorous. The larva is long and slender with six legs. The whirligigs are fond of flying, but must leave the water before they can take off into flight. Just before flight they make a peculiar squeaking sound by rubbing wing covers against the edge of the body.

OTHER DANGEROUS POND INSECTS

In addition to beetles there are other pond insects which should

not be allowed in nursery ponds as they prey upon fry. Yet in ponds containing older fish they may have their uses. These insects include water-boatmen and water-scorpions. Scorpions are of a neutral colour, which can be called 'aggressive resemblance' as they are difficult to see as they lie amongst the weeds in wait for victims. The longish straight tail is of two parts joined together lengthwise, forming a tube through which air passes to its respiratory organs. The scorpion, requiring fresh air, will walk slowly backwards up the stem of a pond weed until the tip of the tube is above the surface of the water. The water-boatmen get their name because they move on the water surface upside down and use their hind legs as oars. These legs are long and fringed. The clawed front legs are used to seize their prey, when the victim is pierced with the sharp, pointed beak. They always attack from beneath.

The other water-bugs are useful as fish-food and as scavengers. All usually have wings and fly from pond to pond in the evenings. There are two insects which are aquatic for the first period of their existence and then become insects of the air. The most beautiful of all such species is the Dragonfly. In its larval stages, in a still-water pond, it is terribly voracious, sharing the reputation of the *Dytiscus* beetle as being a tiger of the water; the larva may spend some years at the bottom of a pond before it emerges as a winged air-insect. In the water the mode of progression of the larva is remarkable. They have a valve in the last segment of their body. Through this they take in water and extract the necessary oxygen. When they wish to move, this valve is opened and the water ejected in a powerful jet, and this propels the insect forward. Perhaps the term for deceit—'two-faced'—originated from the fact that this larva has two faces, used to deceive. It lies up in the mud, all but its head covered, waiting for young fry, tadpoles, etc. When the prey is near enough the second face—an elbow-jointed jaw—extends in a flash and seizes the prey and conveys it to the larva's mouth.

The May-fly, much beloved by fish as a delicate morsel of food, also has a larva, which may be a pest to fish farmers with flowing water ponds. If artificial redds are made in such ponds for open air hatching, the may-fly larva will attack the ova. They pierce the eggs with their sharp nippers. They will also attack ova in natural streams.

Snails, and the scores of other inhabitants of ponds, are all useful

as scavengers as well as for fish-food. The only snail, if minnows are being bred, which may be troublesome is *Limnia stagnalis;* this eats minnows, beetle larvae and other snails.

Nature, doubtless, is doing its utmost toward the 'survival of the fittest' in producing all the pond pests just described. The fish culturist must decide which is the better course to pursue—allow Nature to take her course and then write off losses of fry, etc., or adopt methods of control of predators. Will the expense in labour and materials involved balance the losses? That question has been answered by a large majority of fish farmers of all countries by their adoption of all sorts and conditions of control methods.

PRECAUTIONARY METHODS

Here are some of the methods used with more or less success: Covering screens—Tar paper on wood frames for raceways; rotary screens driven by water-power on circular ponds; cloth screens to reduce algal growth and to exclude birds and other fish-eating animals from raceways and small ponds, and poultry-wire screens on frames or in large rolls for covering raceways and small ponds. The disadvantage in using such screening is its interference with the handling of fish in the routine operations of feeding and cleaning. In constructing screening, fish culturists may improve upon the idea and create a system, which while effective is also convenient, allowing for less interruption in the labour of pond attendants.

Wiring—Wires are strung over the ponds near water level, mostly two feet above the water. The proper wiring to be used depends on the size and location of the body of water to be protected. Wiring on ponds over half an acre in extent is not recommended, although one successful wiring of a two-acre pond is on record. Light wire should be used so that birds cannot settle on it. Cross-wiring, making 24-inch squares, has proved successful in a bird-infested area.

Overhead wiring, about seven feet above the water level, has been successful in raceways and small ponds both in protecting the fish from birds and in allowing labour to carry on without any interference. The wires were strung on permanent metal posts. The wires were six inches apart and ran parallel to the length of the raceways.

Scarecrows on pond banks are not so successful as floating scarecrows on the pond itself. Noise-making devices used by fruit growers have been tried on fish farms, and while successful they were found to be a nuisance by the working staff. These devices include noisy windmills, marine sirens, klaxon horns and gongs, all electrically operated and timed to sound at intervals.

The flash gun invented for the benefit of the fruit growers has proved effective. This is an automatic acetylene detonator. It generates acetylene-gas as water drips on calcium carbide through an adjustable valve from a supply tank. At controlled intervals out bangs a report, resembling that of a shot gun. Simultaneously with the explosion, the gun in its recoil sends out a blue-white flame two feet in length. The gun operates continuously and automatically through a small pilot light. A single filling of calcium carbide will work the gun for twenty-four hours, firing every two minutes. The intervals can be of any length desired. It is only a matter of setting the machine. The cost of the carbide for one filling is a matter of pence only, and to clean and refill the gun each day occupies only ten minutes.

TRAPS FOR BIRDS AND BEETLES

Traps are used around and in the ponds of fish farms in the war against fish-eating birds. The steel traps are mounted on poles five feet above the ground surface of the pond. The pole-trap is generally fastened by a chain and sliding ring to a wire which slants from the top of the pole to an under-water position, where it is made fast. When a bird alights and is caught, the trap is knocked over and bird and trap slide under the water. A majority of farms have discontinued these pole-traps as, instead of herons and kingfishers, a host of innocuous birds—many protected by law—were being caught in them.

A barrel trap for large birds is quite a success. Top and bottom of a light-weight barrel are broken out, the barrel is cut so that it stands on end, out of the water of the pond, about 1½ feet. It is painted some dark colour and the top is covered with wrapping paper, with some slits cut in it. Large birds take the barrel for a tree-stump, or something solid, on which to alight. They break through the paper, which is already weakened by the slits, and fall into the water. Being

inside the barrel and having no room to open their wings the birds cannot rise and fly away.

Electrified bird perches and electrified fences around ponds have had no success. Neither have tin cans or squares of tin strung across ponds. The hanging of dead, fish-eating birds, on poles over ponds has very little effect in warning off marauders.

In ponds and raceways with vertical walls, rising two feet above the water level, the fish are less vulnerable than in ponds with gradual sloping sides. Frequent trimming of grass and vegetation around the ponds and raceways creates a less-favourable environment for the approach of enemies.

The best trap for beetles is to place a night-light, protected from wind and rain, in a pile of fine dust situated on the bank of the pond. Beetles are always attracted by lights at night. They get into the dust and are immediately rendered helpless.

The concentration of fry in a pond, especially around the water inlet, leads to their greater vulnerability. A plan or device to prevent such crowding together and to give a more even distribution of the fish is badly wanted. Experts to date have been unable to suggest any successful solution.

CHAPTER XVII

TREATMENT OF AILMENTS AND DISEASE

In many big cities of the world there have been established aquariums in which species of freshwater and marine fish have been exhibited. Elsewhere, fish farms and hatcheries came into being after the rediscovery of artificial propagation. Thus again man, by domesticating wild life, has broken the laws of Nature. Ailments and disease began to appear in the tanks of aquariums and in the ponds of hatcheries. Microscopic organisms—bacteria and protozoa—became pronounced and pathologists had to be called in. In the various aquariums and ponds these experts were able to pursue their studies at close quarters. This was—and still is—a great advantage. The consequence is, that in the aquicultural world, a very considerable list has been compiled of ailments and disease of fish, the symptoms and, above all, the remedies. Many on this list are troubles which occur in aquariums. Those that may occur at fish farms and hatcheries are assembled in table form in this chapter. This has been arranged that the fish farmer should be able, very quickly, to adopt remedial action. He should call to mind Lombroso's terse sentence: 'To help living life it is better to guess quickly than to carry out minute investigations.'

PARASITES

Wild fish, in their native waters, are seldom attacked by parasites. It is in the crowded troughs of the hatchery, or the ponds of the fish farm, that parasitic attacks occur. Every fish culturist, to guard against an outbreak, should be careful not to overcrowd the fish. Sorting out can also be done more frequently and the larger fry removed from the troughs to ponds or from raceways and ponds to

other ponds. Here can be seen the advantage of having plenty of small ponds.

Some knowledge of ailments and diseases most liable to occur should be in possession of every hatchery or fish farm. It is well to have a wooden or metal tank, aquarium or tub, placed in the open in some shady spot or in an open shed just outside the hatchery and consider this the sick bay, using the receptacles only for treatment of ailments. Serious trouble, if it comes, is usually among the fry, and during the warmer weather of late spring, summer or early autumn. One may want to give the fry or yearlings treatment as a matter of interest. If there are valuable fish affected, such as adult trout, brood fish or some specially purchased or imported strain, by all means give them a chance by immediate attention and treatment. Otherwise, if the disease is a major one, it is advisable to accept the loss and kill the affected fish, and be sure to burn the bodies at once.

THE MORE COMMON AILMENTS

The most common ailments are infestation of the gills, fins, and bodies of fish by protozoa of several kinds. Then there are the trematoda, composed of various worms. These external attackers can be killed off by immersion of the fish in a chemical solution. Protozoa are classed as of the animal kingdom; bacteria of the vegetable. It is bacteria which causes the diseases as distinct from the ailments. There is the salmon and trout disease of furunculosis and, among a few others, gill disease and fin rot. Much work has been done on these diseases by pathologists who, of course, are interested, as may be also many zoologists. But the fish farmer's interest must be to prevent such diseases in the ponds as much as possible. There are hundreds of fish farms, large and small, which have been free of all such diseases and have suffered only mild attacks of the minor ailments.

The commoner ailments and diseases which can be at once recognized, and remedial action, therefore, immediately taken, are: Gyrodactyliasis; Fungus; Asphyxia; tail or fin rot; Popeye; Anaemia; White Spot; Blue Sac; Soft egg. The last three are confined to ova and the alevin stage, the others may occur in ponds. Unorthodox remedies may, occasionally, be successful, but it seems better to rely

on those suggested by the pathologists, who have effected cures, after many laborious experiments and much research into results obtained from the use of various chemicals.

Soft snow is not a prescribed remedy, but it is related that an aquarist, not wishing to go through the process of killing an aquarium full of sick and dying fish, threw them out into the soft snow to die a peaceful death. Next morning the fish were all alive and flapping. They were put back into an aquarium with a flow of fresh water and lived happily for some years.

In treating a fish for some ailment it should be remembered that handling is dangerous to the fish. It must be realized that the eyes of fish have no lids and, therefore, no protection. They are liable to injury from the pressure of the hand or the net, if the latter is not of the right kind. Nets with knots should not be used. 'Not Knotted Nets', might well be a hatchery slogan. The dip nets should be of a soft, though strong, netting such as is used for window curtains. If fish are bruised in handling it may go hard with them. Rough treatment or pressure will not break any bones, but will cause the bruise to enter the tissues and muscles, and this is fatal. A point in all remedial action that is often unrealized, is that fish differ in response and resistance, not only specifically, but individually, as does all life.

FUNGUS—THE WATER MOULD

In the past the bugbear of all hatcheries has been fungus, a water mould, which reproduces minute zoospores in enormous quantities. Any abrasion on the skin of a fish, any cut, wound or bruise, is quickly seized on by the zoospores, and a characteristic whitish, cotton-wool-like tuft appears on it. Unless attended to promptly, the infection will increase and soon cover the whole body of the fish. Fungus also attacks ova and, of course, all dead eggs, dead alevins or dead fish. Years ago it was considered fatal, and on its appearance the fish concerned were killed and the bodies buried while hatcheries and ponds were thoroughly disinfected. In those days a noted authority wrote: 'There is no word in the fish breeder's vocabulary that is so associated with loss and devastation as the word "fungus". There is nothing with which he has to deal so insidious and deadly as fungus.'

This statement, nowadays, is only part of the story and all fish breeders will appreciate the great value of scientific research, for pathologists have studied fish disease so thoroughly that they are now enabled to give information as to the cause, suggest a definite remedy and steps toward prevention. Fungus to-day, still insidious, still deadly if neglected, can be considered a warning signal for every fish farmer that something, somewhere in hatchery or pond, is wrong and must be promptly righted. A famous pathologist, the world's most noted authority to-day on fish disease, has made this statement: 'As fungus is always easily recognized, infections by this parasite have assumed an importance among fish culturists out of proportion to its actual potentialities for harm. Usually the appearance of fungus is an indication of the presence of some less conspicuous and more insidious agent, which is the real cause of the trouble. In other words, the appearance of fungus is a warning signal that no fish culturist should disregard, but which in itself may be relatively unimportant.'

CONDITIONS LIABLE TO BRING FUNGUS

The abrasion on a fish may be caused by protozoa or bacteria which, unobservable, have fastened on gills and fins, sucking blood or eating them away; by the bites of rival male fish at spawning periods; by fry nibbling each other; by predatory beetles or insects; by attempted cannibalism; by some unknown accident. Fish in poor condition are, no doubt, the easiest victims of fungus. If there are many in such poor condition, there is something wrong. The diet may not be suitable nor the water. There may not be enough flow or enough water. The fish may be overcrowded. Cannibalism may become rampant; due to the small fry being left with the bigger fry. The pond may be foul from dead fish or decayed food lying on the bottom. Fish may be over-fed or may be starving. Whatever may be wrong, the fish farmer, having received the signal from *Saprolegnia ferax*, the scientific name for fungus, must investigate and set things right.

Should any fish show signs of starvation, it may be because it has gone blind and cannot see to eat. Blindness will be quickly noticed, for the fish change colour rapidly and become black. This infirmity is incurable. The fish should be killed. The origin is uncertain as yet.

It has generally been put down to foul water, but this has been disproved. It is, perhaps, due to zoospores. A trout, in a stream, may be seeking food near a decayed log or other piece of wood which has, partly or wholly, a fungus growth. The eyes or eye might contact zoospores. It is to be noted that a majority of the few blind fish are only blind in one eye. Black ophthalmia is not common and is quite rare in controlled ponds. It may affect trout of any size. A blind fish automatically turns black. The nervous stimulant governing the distribution of pigment in the cells which lie under the skin of the trout, turns it light or dark, because it is controlled by the action of light or the absence of it, on the retina of the eye. When a trout goes blind in one eye only, the body on the side opposite to the blind eye will turn black, while the other side retains normal coloration.

THE REMEDY FOR FUNGUS

Small fish, fry or minnows, will eat the fungus growths on a bigger fish, and the big fish in return for such service do not attempt to eat the smaller fish. The remedy for fungus itself is salt; wipe the fungus off with a cloth dipped in salted water, then give the fish a bath in a saline solution until they show signs of distress, whereupon they should be removed to running water. As a preventative measure, place salt on the apron of the trough or pond and let the flow dissolve and distribute it.

Prevention of any disease is best attained by strictness of routine in keeping the hatchery absolutely clean; in removing dead ova and dead fish immediately, also in removing rotted surplus foods, dead fish and other decaying debris from the bottom of the ponds. This cannot be too much emphasized, as such conditions give protozoa and bacteria the opportunity to increase and become a menace.

MEASURES TO AVOID DISEASE

Ailments and diseases attack fish that are in a weakened condition. It is, of course, the aim of every fish farmer to have and maintain his fish as healthy and vigorous as possible. If there is any sign in any pond of distress or appearance of weakness action should be taken

at once. The addition of cod-liver oil to the diet or a change of diet, may help. A change of water may indeed be required or the removal of half the population of the pond because of overcrowding. If the pond be still-water it may require more aeration, which can easily be given by a spraying pump. If there is a flow which comes from a pond holding older fish—such water is not good for fry. Such measures comprise the first assistance which can be given to fish in a weakened condition. The fish farmer must be quick to recognize disease in its earlier stages and immediately take steps to control it. With the diseased fish promptly removed the next step is to give remedial treatment to the remaining fish in the pond. Obviously it is impossible to give medicine internally to fish. For all freshwater fish, the use of salt is a safeguard against fungus, ailments, disease, and some enemies.

Copper sulphate and permanganate of potash are used to counteract bacterial diseases. Permanganate is also used for external troubles. Acetic acid and formalin are used mainly against external parasites. It is possible to give treatment in solutions of any of these chemicals to a few fish, in the sick bay. But when many fish are concerned the only way of dealing with them is to give a wholesale treatment in the ponds. If there is a flow of water this should be stopped for the period of the treatment.

EXTERNAL TREATMENTS

The latest, and considered the best, treatment for external parasites is to put into the pond a solution of formalin—the ratio being one part per four thousand of water. The gallon capacity of each pond should be known at the fish farm. It is calculated by multiplying the length by the breadth by the average depth and then by 6¼. As an example: Pond with an average depth of 3 feet, length 30 feet, breadth 20 feet, multiplied together equals 1,800 feet and multiplied by 6¼ gives a capacity of 11,250 gallons. The formalin required for the solution for a pond of that size would be about two and a half gallons. The easiest way in which to introduce the formalin into the pond is to place convenient receptacles on the bank of the pond—two fifty-gallon tanks, or tubs, barrels, even pails—and make up a solution in them of the two and a half gallons of

formalin to one hundred gallons of water taken from the pond. This mixture must be distributed evenly over the whole of the pond. The best means of doing this is to spray it by means of a stirrup-pump, using the spray nozzle. In smaller quantity this solution works out at one pint of formalin to five gallons of water. The formalin solution being distributed—the flow of water, of course, being stopped—the treatment should continue for one hour. Then the flow is restarted and increased for a time.

For bacterial infections copper sulphate or permanganate of potash are the main chemicals used. But there are many difficulties attached —particularly to copper sulphate—to the treatment of fish of all ages. Hard water makes copper sulphate less effective as a disinfectant, while soft water increases its power so that in soft water the solution must be made weaker. In too strong a solution, or too long a treatment, the copper sulphate also hardens the mucous covering of the body and gills of a fish, thus interfering with respiration, and the fish may be asphyxiated. Sometimes, a heavy loss has been attributed to toxic poisoning, when the fish have really died from asphyxia. To obviate asphyxiation, salt should be added to the copper dose, because salt removes mucous and will soften the hardening effect of the copper. The usual solution is one part of copper sulphate, by weight, to two thousand parts of water. The powdered form of the sulphate is the most convenient to use. The strength of this solution will have to vary according to the waters, but it must not be exceeded. Chemical action is quicker as temperature rises, so the length of time of treatments in summer should be less than in the colder weather.

The treatment in this solution of copper sulphate should be given in the sick bay in a container large enough for the fish to swim about. The period of immersion is from one to two minutes. Weak or much distressed fish will probably be killed, but the others, the hardier and healthier ones, should at once be put into running water. To use copper sulphate or permanganate of potash in ponds, raceways or hatchery troughs containing fish the solution is very much weaker, as follows: Copper sulphate, 1 in 100,000 parts of water, and Permanganate of potash, 1 in 150,000 parts of water.

DEVICES FOR SPREADING CHEMICALS

There are several devices of siphons, and such, where the proper concentration of the chemical is obtained by adjusting the strength of the solution to the volume of flow. The simplest plan, although it may be considered rather crude, is to fill a large bottle with the solution, turn it upside down, immersing the neck in a shallow pan. The solution is thus kept automatically at a constant level. To obtain a uniform flow of the solution at the required rate, a tube with the required diameter is attached to the pan. The treatment is for one hour. Then the chemical should be washed out of the pond, raceway or trough, by increasing the flow of water. The treatment can also be given for one hour by stopping the flow of water, provided the water is artificially aerated at, say, the half-hour and the three-quarter hour, in case the flowing-water fish use up the oxygen too quickly. Treatment of still-water fish should take place in a pond where a flow of water is available to wash out the chemical after the treatment.

STERILIZING THE PONDS

In the sterilization of the ponds themselves, the easiest and the least expensive is to empty it first, leave it exposed to the weather for a couple of days and then treat it with lime. Make up lime milk with one part of slaked lime to four parts of water. Then sprinkle this generously and thoroughly all over the pond, the walls or banks, bottom, the inlet and the outlet. Leave exposed for a week. Another method is to use bleaching powder. Spread this on the bottom of the pond near the inlet. Then, having closed the outlet, turn on the flow of water. Bleaching powder contains 70 per cent of chlorine. As the powder is dissolved by the water the chlorine is released. Chlorine can also be purchased in liquid form in pressure cylinders, and is put in the pond through a hose attached to the outlet valve of the cylinder. To get chlorine into solution, without much waste, the water in the pond should be disturbed or churned up as much as possible. This helps to break up the gas into smaller bubbles, which are the more quickly absorbed. In using chlorine in liquid form one does not, of course, empty the pond before or after the

operation. Sunshine affects chlorine and dissolves the gas rapidly and in twenty-four hours there should be little remaining. However, before putting fish back into the pond, one can, in order to be quite safe and to neutralize any chlorine remaining, distribute a 5 per cent solution of photographer's hypo (sodium thiosulphate) into the pond. The operator in the liquid chlorine treatment of ponds might be advised to use a gas mask.

Ailment or Disease	*Fish*	*Symptoms*	*Remedy*
Asphyxia.	All fresh-water.	Gasping and distress from being too long without fresh oxygen. Gills perhaps inflamed from sudden changes in water temperature.	Salt in pond. Aerate water.
Anaemia.	All fresh-water.	Gills become pale pink or greyish-white. Due to lack of meat in diet.	Feed fresh liver or other meat.
Blue Sac.	Trout Alevins.	Enlargement of yolk-sac. Alevin unable to rise to surface.	None. Believed due to rough handling of ova.
Costiasis.	All fresh-water.	Light bluish or greyish film spreading over body and fins. Loss of appetite.	One hour's immersion in formalin. Solution 1–4,000.
Constipation, Indigestion.	Goldfish and others.	Fish sluggish. Lie on pond bottom or stand on head. Abdomen swells.	Castor oil or Epsom salts. Immerse in bowl of oil or salts for two minutes. Remove to bucket of water until oil has risen from body. Drain off and return to pond. Can feed earthworms. Otherwise no food for three days to one week.
Egg-binding.	All.	Loss of appetite. Bloated condition due to gas from decaying eggs.	Net and strip in usual manner. Insert small forceps or rose-stick in vent. Gently press from pectoral fins toward vent. May be repeated in a week if trouble continues.

Ailment or Disease	*Fish*	*Symptoms*	*Remedy*
Gyrodactyliasis.	Goldfish. Trout. Other pondfish.	Bluish-grey slime on dorsal and caudal fins and gills caused by parasite. This fluke bears living young which before birth contain young of third and fourth generation.	Common salt. Immersion for 1 to 1½ minutes in strong salt solution—2½ ozs. to gallon—kills flukes. Prevention if pond is salted occasionally.
Fin and Tail Rot.	Goldfish, pondfish generally.	Bacterial infection of dorsal fin spreading to other fins and/or tail. White line appears along outer margin of fin or tail. Fins and tail will become badly frayed.	In earliest stage dip fish for one to two minutes in solution of 1 to 2,000 copper sulphate. Several treatments at intervals of 24 hours may be necessary. Alternatively run dilute solution copper sulphate through pond or trough for one hour. Beyond earliest stage kill all infected fish and burn bodies. Disinfect pond.
Gill Disease.	All fry.	Loss of appetite. Gills swollen and deeper red than normal.	Treatment as above.
Fungus (saprolegnia ferax).	All fish and ova.	White cottony tufts developing on wounds or on scales.	Immerse in strong salt solution, sponge body while submerged wiping off the white tufts. Give other fish in pond or trough treatment with dilute solution of salt flowing through for one hour.
Popeye.	Trout. All pondfish	Marked protrusion of eye-balls. Several forms due to water super-saturated with oxygen, others to kidney troubles or bacteria. Seasonal in spring and early summer.	Transfer fish to warmer water.

Ailment or Disease	*Fish*	*Symptoms*	*Remedy*
White spot.	Ova and fry.	White spots on eggs and fry. Primarily caused by injury to the ova in transport, handling or being frozen.	None.
White spot. Also Itch.	All fish.	White or greyish pimples on body. Fish rub against sides or bottom of pond to rid themselves of the parasites. Not common to fish in flowing water.	Various remedies. Put into running water for several days. Salt may be added to ponds or troughs. 3 per cent salt solution. One hour in 1 to 4,000 solution of formalin. Pond should be sterilized with quicklime or chlorine.
Soft egg disease.	All fish.	Disease appears after eggs are spawned. Eggs become soft and flaccid due to minute openings in egg membrane.	Rigid sterilization and antiseptic methods. In spawning and washing eggs clean spring water should be used. Then treat eggs with strong salt solution. Troughs and all receptacles and tools should be frequently and thoroughly cleaned and sterilized.

Quite recently fishery research has begun to show the importance of iodine in fish life. It has been proved to be a tonic, to cure and to help prevent disease and to develop and increase the growth of fish. When absorbed, the iodine goes to the thyroid gland, from there it is later distributed, as an organic compound, to the fish's organs and tissues.

Seawater and seaweed, from which the world's supply of iodine comes, is comparatively rich in iodine, especially decaying seaweed inshore. Seawater itself, away from plankton which contains much, averages only about 18 y per litre. (y is one millionth of a gramme.)

Freshwater in this country averages only 1 y per litre. Limestone, of all rock formations, is the only one which contains a fair amount

of iodine; in others there are merely traces. Perhaps that is why chalk streams are good trout rivers.

Iodine in freshwater is also found in plants, especially pond weed and water-cress. In land plants the amounts are so minute as to be scarcely traceable.

Experiments have shown that in iodized water trout have increased 25 per cent and rainbows 30 per cent above normal growth.

In fertilization experiments iodine had no effect on ripe ova or sperm but unripe spermatozoa and unripe ova were activated.

Iodine, as is well known, is much used in medicine and veterinary practices in curing and warding off diseases. At a fish hatchery it has been used with success in an epidemic of goitre among young trout. There was a scarcity of water and much overcrowding. This brought on goitre. Iodizing the water not only effected a considerable cure but warded off the disease from older trout in other ponds just as it was starting to show. After forty days the trout were well and showed the tonic effect of iodine by their enhanced colour.

Two methods to iodize the water are given as follows:

One cubic centimetre of Tincture of Iodine (composed of five grammes of Potassium of Iodide and seven grammes of Iodine dissolved in 95 per cent alcohol). This was added daily to the ponds. The other is: one to two milligrams of Potassium Iodide to each two pounds of trout in the ponds. This dose also is a daily one.

The research shows definitely that fish can absorb iodine in inorganic form from the water, absorbing it through the skin.

CHAPTER XVIII

COMMERCIAL ASPECTS

The aquiculturist, or the man or woman who intends to take up aquiculture, has a large field in which to work. Culture on a small scale as a hobby and pleasure is, of course, not in question. A water-farm can be established on a commercial basis, and, with certain provisions and under certain circumstances, can be a success with good financial returns. The provisos are that one must be interested in the work and that work must be under a self-imposed discipline. The conditions are that the site is well-chosen and that the water supply is adequate all the year round. It is understood, of course, that the necessary capital is to hand—a few hundred pounds or a few thousands, depending upon the type of cultivation and the size of the farm. The types may be divided under three headings:

1. Fish.
2. Other aquatic animals.
3. Water plants.

Fish come first. Salmon and trout are the luxury fish. There are a dozen or so trout farms in Britain, mostly established for many years. Some of the Fishery Boards throughout the country breed the salmon and trout for re-stocking the rivers over which the Boards have jurisdiction. Some angling clubs, water companies and riparian owners also pay attention to the breeding of trout to restock their waters. Yet, despite such factors, the restocking market is wide open for a good many more thousands of young fish.

LUXURY MARKETS

Then there is the luxury market which is inadequately supplied by existing trout farms. One must consider the state of affairs on the

Continent and realize that the import of fish is now practically, and for some years to come, perhaps, non-existent. The luxury market consists of hotels, restaurants, guest houses, passenger ships (liners), fishmongers, and possibly railways. Contracts with some of these can be a paying proposition. Continental countries are also importing our trout. Take a lesson also from our water companies and from some of our landed gentry with ponds and lakes on their property. They stock their waters with trout and advertise the fishing. Anglers from all over the country buy either season tickets or day tickets, as the case may be, for the trout fishing. These are subject to the usual restrictions, imposed by the owners. So many trout of legal size may be caught and taken away; smaller fish must be returned to the water. Practically all the big reservoirs are being fished by anglers paying for the privilege. Ponds and lakes belonging to private estates are fast following suit. The income is considerable. One must remember that most, if not all, of the reaches of our trout rivers have riparian owners or exclusive clubs possessing the sole fishing rights. There is an army of enthusiastic fly-fishers—and many potential ones—who crave a day with the trout and are willing to pay for it. American farmers with ponds and lakes have for some years turned their waters into profit-making ventures by selling angling tickets. If the waters be large enough they establish bathing pools and boating in addition.

CATERING FOR ANGLERS

Catering for an angling world can be done on a trout farm without much disturbance to the main purpose of raising trout for the markets. Or, if the waters are extensive, the angling side of a venture can be placed first with a small hatchery attached for the purpose of supplying fish to the ponds and lakes for the angling.

A trout farm must possess a hatchery, even if eyed-ova are purchased. One can, of course, take chances of hatching these out in ponds or sections of a stream, thus dispensing with the hatchery, but for commercial fish farmers this is not advisable. There is more work attached to a trout farm than to other fish farms and, although the luxury market is limited and prices uncertain, the returns are quicker and, perhaps, on a higher scale: a beginner, buying eyed-ova and fry from another trout farm, within a year should have for sale,

for restocking, yearlings and hatched fry. In the following year the food market would be within reach.

Another food fish, the carp, has been the principal money-maker for aquiculturists on the Continent. A carp farm does not require a hatchery, nor all the initial outlay attached to trout farms. Nature attends to the spawning and hatching in the ponds. The main labour is in the feeding. But the carp market is peculiar in that, being the favourite fish dish of the Jewish and Continental people, demands come only from the big towns. The general public needs educating in the art of cooking this fish as well as other freshwater fish. These latter are unfashionable, unmarketed and known, mostly, only to rural communities. Some recipes, including methods of ridding the fish of muddy flavour, are given in order to help the carp, especially, to figure more largely on the food markets.

THE GOLDFISH FARM

The present era is a golden one for the goldfish culturist because of the prevailing high prices, such situation being due to the fact that imports from Italy, Germany, and the U.S.A. were stopped by the war and have not yet been resumed. As it was easier and cheaper to import from the Continent there was no extensive breeding of goldfish in this country. Wholesalers, jobbers, dealers, pet shops, multi-article low-price shops and bazaars comprise the market, but an enterprising goldfish farm, by advertising, could create its own market and sell retail. Its customers would be the tens of thousands of people with aquariums and garden ponds and, also, the breeders who are always on the look-out for new blood, perfect in shape and colour, for their brood stock. The goldfish culturist would have more labour than the carp farmer in that it is more prudent to convey the vegetation on which the fish have spawned to indoor aquariums for hatching.

The very latest subject for fish culture is the mullet. This delicious table fish is just being introduced into freshwater farming in the western world. The Chinese have been rearing it for countless years. Quite recently Americans began experimenting, first in brackish water, then in freshwater. The successful results may mean a boom in mullet cultivation. To market it will not be difficult.

There are many other fish which can be bred for a purpose or held in ponds for fattening.

FATTENING EELS

Yellow and silver eels, fattened with plenty of food, can be held in any muddy enclosed water. They cannot be bred, of course, but can be trapped from any river or lake. Most riparian owners are only too anxious to get rid of eels and would, doubtless, give permission to legitimate trappers.

Another fish worth breeding is the perch. It can either be bred for the table or for its fry, which are excellent food, much favoured by adult trout, or those just leaving the adolescent stage. These fry could be sold wherever natural food for fish was wanted.

Other fish, the cultivation of which are commercial possibilities, include tench, roach, rudd, and minnows. Tench for the food market and also, with rudd, for garden ponds and pools. The roach, rudd, and minnows are required for bait by anglers, especially by pike anglers—an increasingly popular sport. There is a special market for fancy goldfish—not tropicals, for such require heated indoor aquariums. While fancy fish might be included in the goldfish farm they are subjects worthy of a farm to themselves. These fancy fish include those goldfish known as Comets, Fantails, and Shubunkins, which are great favourites with ornamental pond and aquarium owners. Then there are Golden Orfe, Golden Rudd, Golden Tench, Mirror or King Carp, Sunfish and Catfish. There are, of course, many other fish, but the demand for them is small; there is no general market and the commercial prospects are inconsiderable.

EDIBLE FROGS—WATER PLANTS

Other aquatic animals, with markets which have an increasing upward trend, are edible frogs and natural foods such as freshwater shrimps, mussels, limpets, whelks, winkles, and snails. Edible snails may also be in the picture, although they prefer land to water.

The fish farm in general can put upon its sales list the best types of water plants. There is a good demand, though it is not advisable

for the aquiculturist to create a water farm for the sole cultivation of water plants, but as a side line it is definitely recommended.

Another saleable commodity which has a market among garden pond and pool aquarists is water from the natural food ponds. This water, full of microscopic aquatic life, infusoria and larvae, is used to inoculate the pond or aquarium water and so sold by the gallon.

When the aquiculturist has decided upon the type of farm to establish there must be taken into consideration that, for the first year, there is little opportunity of much, or any, monetary return. But once established, contracts as already outlined should be sought and a modest advertising campaign begun. Advertising in Sunday newspapers and the periodicals devoted to, or interested in, angling or aquariums, should bring in many orders. A booklet or small catalogue is also a necessity. It should be well printed. A cheap, shoddy print is detrimental.

EYED-OVA AND FRY

Eyed-ova and fry (ready to feed or eight weeks old) are sold by the thousand. Trout from yearlings upward, by the hundred, and gold and other pond fish by the dozen. Because of the demand exceeding the supply, goldfish are now largely sold at so much apiece or in pairs. On contracts to hotels, etc., table fish are sold by the pound, gross weight. Eels are also sold by the pound.

Supply and demand govern the prices. Varying discounts are given on orders for ova and fry on quantities from ten thousand to one hundred thousand. With most fish, especially trout and goldfish, the price is in accordance with size. Standard sizes recognized by dealers are as follows:

TROUT

Yearlings	*Size in ins.*	*Two-year-old*	*Size in ins.*	*Three-year-old*	*Size in ins.*
Small	.. 3–4	Small	.. 7– 8	Small	.. 10–11
Small	.. 4–5				
Medium	.. 5–6	Medium	.. 8– 9	Medium	.. 11–13
Large	.. 6–7	Large	.. 9–10	Large	.. 13–14

GOLDFISH

	Size in ins.		Size in ins.
Small	$1\frac{1}{2}$–2	*Fantail*	
Medium	2 –$2\frac{1}{2}$	Small	$1\frac{1}{2}$–2
Medium large	$2\frac{1}{2}$–3	Medium	2–$2\frac{1}{2}$
Large	3 –4	Medium large	$2\frac{1}{2}$–3
Extra large	4 –5	Large	3 –4
No. 1 Fountain	5 –6	Extra large	4 –5
No. 2 Fountain	6 –7		
No. 3 Fountain	7 –8		
Comet		*Shubunkin*	
Small	$2\frac{1}{2}$	Small	2
Medium	$2\frac{1}{2}$–$3\frac{1}{2}$	Medium	2 –$2\frac{1}{2}$
Large	$3\frac{1}{2}$–$4\frac{1}{2}$	Large	$2\frac{1}{2}$–$3\frac{1}{2}$
Extra large	$4\frac{1}{2}$ plus	Extra large	$3\frac{1}{2}$–5

Now just a word about marketing the side line of the fish farm—water plants. Wholesalers for water plants are not yet in evidence, but some of the bigger aquatic dealers are frequently willing to buy in quantities to fill their orders. It is advisable to keep in touch with them. But in visiting and getting acquainted it is well to remember the old tag 'cum grano salis', for a pinch of salt is often a necessary corrective to their pessimism when meeting other members of the trade. Water plants are much in demand by ornamental pond owners, water garden lovers and people with aquariums of all sizes and sorts. Some of the cultivated, rarer plants (see Chap. XI) are sold singly. There are a number of other varieties, suitable for ornamental purposes and beneficial to the fish, which are sold by the dozen. Then there are the more common ones, sold by the hundred. The question may be asked: Why should anyone pay for the common water plants when they can get the wild ones from any stream or body of water by merely pulling them out? The answer includes many reasons. The principal one is that the wild plant may bring disease and enemies to your water; the microbes or larvae may not be visible but will develop. Again the plant, indiscriminately pulled, may not flourish with the change to unsuitable soil and water. Naturally the aquiculturist, with many plants growing in his ponds, can

guarantee clean and healthy ones, free from trouble for the customer and, moreover, can advise on the most suitable plants for the variable soils and waters. It should be mentioned, in advertising, that the plants are cultivated from selected stock and grown in clean and controlled waters. Small quantities of plants can, of course, be sent by parcel post.

IMPORT REGULATIONS

Of some importance to fish farmers and breeders, as well as dealers, are the conditions governing the import of live fish and live ova.

Import into Great Britain of live fish of the salmon family is prohibited under an Act of 1937. The import of any live freshwater fish or live eggs of fish of the salmon family or of freshwater fish is also prohibited except under licence. The licence is issued by the Ministry of Agriculture and Fisheries, authority for which is granted by the Board of Trade, Import Licensing Department, 189, Regent Street, London, W.1.

Fish and fish ova pay an *ad valorem* duty of 10 per cent except under Imperial Preference, when, if they are from British waters, fish or ova are free. A certificate of origin on Form No. 119 (Sale) furnished by the actual breeder or supplier overseas is necessary to substantiate a claim for Imperial Preference.

CHAPTER XIX

TRANSPORT OF FISH AND OVA

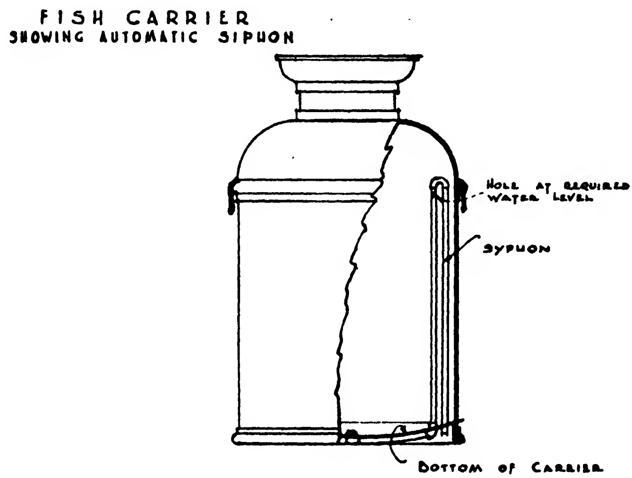
Transport of live fish and ova is one of the bigger problems of a fish farm. When one has to transport a small number, say a dozen eight-inch trout, only a few miles, these may be safely carried in a metal container holding two to three gallons of water. But when an order has to be filled for several hundred fish to restock a water a long distance away—and every commercial fish farmer hopes, expects, and usually will receive such orders—it is a matter of several containers going by rail or delivery by lorry. The personal delivery by a lorry, specially fitted with fish tanks and aerating plant, is the most modern method.

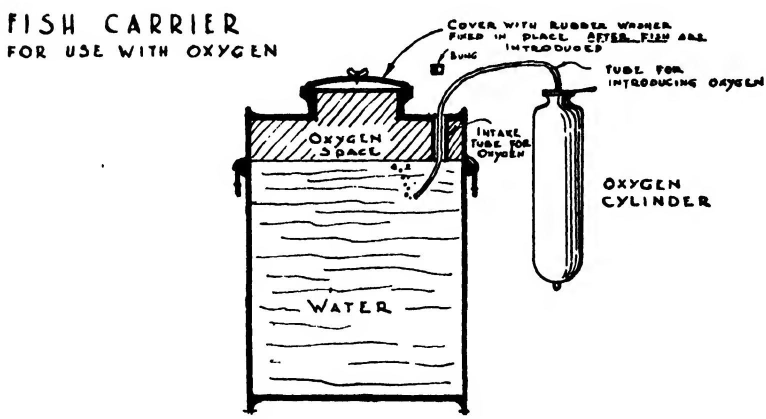
An extra charge in such cases is made for delivery. This is generally less than railway charges. Smaller orders are free on rail, carriage forward. Customers are required to return the empty cans by passenger train, carriage paid. While fish are usually sent at customer's risk, some hatcheries guarantee live delivery, pay carriage and other expenses such as sending an experienced man with the shipment. In such cases additional charges are made and included in the price of the fish. Late autumn, winter and early spring are the best seasons for transport of fish.

Goldfish are the easiest species to send on their travels. In Germany, when a few fish are ordered for an ornamental pond or aquarium, moss is steeped in beer and stuffed into the mouths of the fish; these are then laid in damp moss in a box so packed with moss that there can be no movement inside, and shipped. Many have journeyed in this way for forty-eight hours without mishap. Goldfish have also been shipped in a metal container, which had a slow leak; the fish survived, although they had to breathe damp air for four days instead of being under water.

An old-fashioned way of shipping fish was to use a well-scrubbed

or new barrel; half fill with water and after putting in the fish, tie or tack a cover of sacking, plentifully provided with air-holes, over the top.





CONDITIONING FISH FOR TRANSPORT

The trouble in transporting live fish over long distances is that the water in the containers becomes de-oxygenated by the fish and by their excreta, which soon covers the floor of the container. Because of this excreta it is very necessary to keep the fish foodless for

some hours or days before shipping. For small trout-fry twenty-four hours; for six- to eight-inch fish, forty-eight hours and for adults four days. This is generally known as conditioning. Sometimes the fish are put into conditioning boxes of wood with sides and ends of meshed wire, five strands to one inch, placed in running water. But too much handling of fish is not advisable and if, when caught for shipment, they can be placed in an unfertilized pond, that should answer the purpose and be more beneficial to the fish.

This conditioning may soon become unnecessary in that containers have now been invented which siphon out the bottom water-debris and excreta and also have an aerating device. These Fearnow Containers are patented and they can be purchased on the American market. The inventor is a high official of the American Fisheries department. His self-aerating container is only 12 inches high by 13½ inches in diameter. It carries as many fish as a ten-gallon milk can. His siphon invention is in the shape of a capital U and can be attached to practically any container.

Containers have been designed in many countries, mostly with the idea of having as much water surface as possible compatible with the easy carrying of the can. A most successful one for easy carrying is made of galvanized iron and has a base of 18 inches diameter. The sides of 6 inches slope at an angle of 45 degrees, with a length of 8 inches to the neck, which is 6 inches long. There is a handle on each side. These are strengthened by an iron band passing underneath the container. The empty weight is 15 lbs. It should contain 4½ gallons of water, which makes a total weight, without fish, of 60 lbs. The milk can, which has been much used as a fish container, has little water surface and is now much out of favour at hatcheries. A squat can, shaped like the milk can but half its height and twice its diameter, with a hinged, perforated lid, has been much used in recent years.

GOLDFISH SHIPPING

Goldfish shipping cans differ slightly from those used for trout. The ones in general use are round in shape, eighteen inches in diameter with sides eight inches high, sloping five inches to a top collar two inches high and ten inches in diameter. The cans, of the usual

heavy galvanized iron, are made in several sizes to hold from sixty to one hundred and twenty gallons of water for one hundred to one thousand goldfish. From results of experiments made, it can be stated that goldfish are not dependent on the oxygen content of the water, that the surface area of the water is more important than the depth and that, therefore, the amount of water in the containers may be materially reduced from the half or three-quarter filling which, until recently, was a standard. As a gallon of water weighs ten pounds, such reduction in future will make it easier to handle the loaded cans.

When not in use never stand the containers or cans on their bottoms. Thoroughly wash them, always lid them, and then turn them upside down. This will prevent any toxic matter or disturbing fish-enemy getting inside.

The governing factor in the safe transport of live fish is temperature. In shipping, the importance of a thermometer cannot be overlooked.

Individual aquiculturists, like their brothers in rural industry, the agriculturist, hold opinions on certain points connected with their industry, which materially differ. The knowledgeable fish farmer transporting live trout in containers will accept, as a golden rule, the direction: 'Never change the water'. The temperature of live trout is maintained at two degrees above the temperature of the water in which it lives. Any sudden change in temperature is so detrimental that many valuable trout are soon lost. Temperature may, of necessity, vary but the changes must be of the most gradual that is possible. This rule applies to mature fish, fry and ova of all species.

PRECAUTIONS TO BE TAKEN

There are arrangements to be made, and some precautions to be taken, when the fish farmer receives an order for shipment of live trout. First to decide on mode of transport—road or rail. In the former case, work out the route from motor maps for the lorry driver. In the latter, decide on a specified train on a definite day. Shipment is always by passenger train. A direct route or through train is preferable to a change at a junction. The wait, in such a case, may be prolonged and will not be good for the fish in the cans dumped on the junction platform. All arrangements should be noti-

fied to the customer in advance, including the time of arrival of the train or expected time of arrival of the lorry.

Now for precautions. Do not turn the fish into the containers overnight. Have everything ready, but await the arrival of the lorry which may be doing the road journey or merely taking the fish to the railway station. The containers can now be filled to the correct level with water of the same temperature as the basin in which the fish have been assembled. Then with dip nets the fish can be transferred and start on their journey.

PACKING EYED-OVA

Eyed-ova are transported on wooden trays fitted into a wooden box, so packed around with wet moss that nothing can move, no matter which way the box may be turned over. For large shipments the Canadian ova chest is undoubtedly the best. This is a stout wooden box containing seven wooden trays; each tray being 24½ by 14 inches inside measurement, with a division in the centre, making in all fourteen sections 12 by 14 by 2½ inches deep. Two inches of moss is placed on the bottom of the box. The sides and bottoms of each section of the trays are carefully lined with one-half inch of wet moss. This is covered with cheese cloth. This cheese cloth is large enough to double over the ova which are placed on the tray. Each section will take two quarts of ova. These should not be packed too tightly and pressure should be avoided. Ova are one-sixth of an inch in size. On the cloth, now covering the ova, should be placed more wet moss to completely fill the section. The trays, when filled, are stacked in the centre of the box. Two slats are fastened on each side of the trays, holding them together. This leaves a space of four inches all round. Dry moss is packed tightly into this space. Sometimes for a long journey the top tray is filled with loose cracked ice; then a pail of cold water is poured over the ice and allowed to run down over the trays. The top is then packed tight with moss and the cover of the box fastened. In winter, for transport in this country, the ice may not be considered necessary. That will depend on the temperature of before and after packing.

For smaller quantities—such as a few thousand—a smaller box and smaller and fewer wooden trays are necessary, but the procedure

of packing should be the same. In the case of two, three or four small trays, they can be tied together with string instead of fastened by slats.

Instructions should be sent to the customer on what to do when trout or eyed-ova arrive at their destination. In the case of ova the trays should be untied and each in turn immersed in a tub or bowl of water. As much of the moss as possible should be gently floated off. Then the tray is turned upside down and the ova, being heavier than water, will gradually sink to the bottom. Here it can be gathered, washed if required and placed on the perforated zinc trays in the hatchery. When opening the box to unpack the trays, the thermometer reading will probably show that the temperature is higher than that of the water in the hatchery. A watering can with a fine rose should be filled with hatchery water and the trays gently sprinkled. The sprinkling should be very light, say half a pint of water at a time. Use the thermometer after each sprinkle. This operation of blending temperatures may take an hour, sometimes more. However, it is worth the labour involved, for it is on the care taken in this matter that success depends. The proper handling of the eyed-ova at this stage is one of the secrets of good hatching. Should the operation be hurried or other carelessness indulged in, the eggs may hatch, but the alevins will not survive.

OPERATIONS ON ARRIVAL

In the case of trout, on arrival the containers should, without delay, be taken to the water into which the trout are to be liberated. Each container should be placed in the pond or other waters and thermometer readings taken. The temperatures of container and pond may differ—slightly or considerably. If the latter, it may take half an hour or an hour before the fish can be released. They must not be turned into the new water until the temperatures agree. To effect this, the pond water by means of a dipper, should be poured at intervals into the container. This operation must be carried out very gradually, using, perhaps, only a pint at a time. Then, when the result aimed for has been achieved, the containers can be laid down so that the fish can go free. Do not up-end the containers and pour out the fish. Do not put them in a pond with other fish. These may attack and

damage the new arrivals, who will be recovering from their journey and investigating their new quarters and, therefore, quite unprepared to meet an attack.

The fish farmer has no need to worry over laws and regulations concerning his business. The laws which appertain to water are described in Chapter V. Other regulations are to be found in the Salmon and Freshwater Fisheries Act, and of these, only those referring to close seasons are applicable. There are close seasons for game fish and also for coarse fish. During these periods it is illegal to sell or transport the named fish, *unless* they are intended for stocking waters. The dates of the close seasons vary with districts, so that it would be advisable for fish farmers to get into touch with their District Fishery Board and ascertain the dates prevailing in their particular district.

PACKING FISH FOR TRANSPORT

The packing of fish for transport, in cans containing water, has been standardized by experiment and practice. With small-sized fish the count is by length, measured less tail. For larger-sized fish the count is by weight per pound of water.

One pound weight of:	*Pounds of water required*
Goldfish; golden orfe; carp; tench	$4\frac{1}{2}$– 7
Pike; perch; eel	$5\frac{1}{2}$– $8\frac{1}{2}$
Bream; roach; rudd	5 – 7
Trout	14 –21

One gallon of water weighs ten pounds.

Smaller fish are packed according to size. Here is a handy table:

Fish	*Length in inches*	*No. per 14 galls. of water*
Goldfish	2– 4	300
„	4– 5	200
„	6– 7	100
	(Larger by weight)	
Golden Orfe	2– 4	300
„ „	4– 6	150
„ „	10–12	25

Tench	2– 4	500
,,	4– 7	200
,,	9–11	80
Eels	9–18	100
Roach	4– 6	150
,,	6– 9	125
Rudd	4– 6	200
Bream	4– 6	125
,,	6– 8	100
,,	7– 9	85
Carp	2– 4	400
,,	4– 7	200
	(Larger by weight)	
Pike	7–20	25
Perch	2– 4	150
,,	4– 7	125
Minnows	ordinary	600

CHAPTER XX

PREPARATION OF FRESHWATER FISH FOR THE TABLE

While the culture of fish is mainly confined to the game, table, and ornamental species, there is, from a commercial viewpoint, opportunity to devote cultural methods to the species known generally as coarse fish. It is a fact that a few fish farms do breed some coarse fish, mostly to sell as youngsters for bait in the winter pike fishing or to be used as food for the trout ponds. No effort has been made to cultivate them for local markets as table fish.

In the past, excepting in the case of eels, there has been much prejudice against these freshwater fish and considerable ignorance on the subject. The fish at any time of the year must be eaten as soon after killing as possible, for they do not keep well. Then again, because of their life among the weeds and mud of a river or other water they have that muddy flavour, varying in intensity from the nature of the water from which they have been taken and which is the foremost complaint against them as table fish. This objectionable flavour can be eliminated by any of the following methods:

ELIMINATING MUDDY FLAVOUR

1. Keep the fish alive for three days in cool, clean water or in running water. Carp, tench, and eels need from three to eight gallons of water per pound, while pike, perch, bream, and roach from five to twelve gallons per pound. Renew the water at least twice in each twenty-four hours by removing a quarter of the stale water and adding the fresh. The cooler the water and the position of the receptacle the better.

2. Clean the fish carefully. Chill it in the refrigerator or in a basin of cold water. Sprinkle with salt and hang up to dry.

3. Clean the fish. Then wash in cold water to which has been added a sprinkle of vinegar, lemon juice or lime juice. If the fish is to be boiled add one of these acids to the water.

Clean all freshwater fish, small as well as big, as soon as possible. If the fish is to be washed add salt and a little vinegar to the washing water. Wipe with a dry cloth. Dust insides with pepper and salt or brown sugar. Vinegar should be rubbed into the backbone. Small fish should be cooked whole; large fish, if not baked or boiled whole, can be filleted. Medium-sized fish should be split like a kipper. Remove scales if desired, except when cooking *au bleu*. If to be fried with a coating or batter or stewed, the scales must be removed. Fish up to two pounds may be boiled; over that weight, cut into slices or 'steaks' or bake whole after stuffing.

To know when the fish is sufficiently cooked is quite simple by using a fork. The thickest part of the flesh separates easily from the bone. A milky fluid flows if the fish is baked.

Allow ten minutes for every pound of fish and ten minutes over.

In boiling add one tablespoonful of salt to each quart of water and half a spoonful of vinegar or lemon juice.

Freshwater fish are one of the principal foods on the Continent, so that there are many recipes. The German one for stewed carp is a first favourite. Here it is:

STEWED CARP

Scale and clean the two-pound fish. Lay it in a stewpan and cover with beer, allowing it to soak for one hour. Then add salt, onion stuck with four cloves, sprig of thyme, marjoram and bay leaf, slices of carrot, cupful of stock or brown gravy. Stew gently for one hour. Serve on a hot dish with the liquid poured over.

FISH *AU BLEU*

To prepare any fish *au bleu* do not scrape off the scales when cleaning, but pour over it 50 per cent diluted hot vinegar; this gives the 'blue' effect. Cook in cold salted water. The additions, such as car-

rots, celery, onions with peppercorns and parsley, should be cooked separately for half an hour and then added to the boiling pot of fish. Bring large fish to the boil slowly, small fish quickly.

Quantities for four persons, for another method of boiled fish, are given here:

FISH BOUILLON

Two pounds fish; three-quarters pound tomatoes; three ounces onions; one and a half ounces fat; one ounce flour; Oxo cube dissolved in three-quarters of a pint of water; half teaspoon sugar; half teaspoon lemon juice; pinch of pepper; half teaspoon chopped parsley. Dry fish after cleaning and cut into medium-sized pieces. Melt fat in saucepan, adding chopped onions for three minutes. Then put in flour and slices of tomatoes. Pour in meat extract water. Boil gently for three-quarters of an hour. Then pass through a sieve and add the salt, pepper, sugar, and lemon juice. Place the pieces of fish in this sauce and boil them in it for five minutes. Then stir in the parsley and serve.

FRIED FISH

In frying freshwater fish, clean very thoroughly and remove the scales. Wash and scrape the fish inside and out, taking care to remove all traces of blood and slime. Rub fish inside and out with salt and hang it by the head in the air for some hours—twenty-four hours is not too long. Take it down, cut off head and roll the fish in whatever coating available. If not batter or breadcrumbs, then oatmeal, barley or maize flour are good substitutes. Fry to a nice brown in oil, dripping or margarine. Sliced onion or apples fried with the fish are considered by some as an improvement. Large fish should be cut into slices about two inches thick for frying; slices should be somewhat thicker if eels are being fried.

BAKED PIKE

In baking pike, size from three to ten pounds, stuff with veal stuffing, sage and onions or sausage. Baste often with dripping or place two or three thin slices of bacon across the back of the fish.

Another method for baking is to roll the fish in breadcrumbs or oatmeal. Rub a dish with onion, place fish in it, sprinkle with salt, pepper, chopped herbs and grated cheese. Place a knob of margarine here and there on top of the cheese. Bake in a moderate oven. Serve with a piquant sauce. Should there be any roe this can be parboiled, chopped fine, flavoured to taste and used as stuffing.

COOKING EELS

Eels should always be skinned before they are cooked as the skin would spoil the flavour. To kill the eel divide the spine just behind the head, but do not cut the head off. To skin the eel, first cut through the skin all round, just below the gills. Then stick a metal skewer through the head. Holding this in the right hand, take a coarse towel in the left hand and grasping the fish tightly below where the skin has been cut through, strip off the skin. Eels should be cooked slowly; they take longer to cook than other freshwater fish. Eels for frying should be opened up entirely and the bones removed. Cut into four-inch lengths, dip in flour, batter or bread-crumbs.

FRY THE PERCH

Perch should be fried. Cut them open like a kipper. Sprinkle with salt, pepper, and a little brown sugar. Put them aside for one or two hours to let the sprinkled seasoning soak in. The flesh will come away easily from the skin when they are cooked.

Roach can be made into 'Rollmops' as with herring. Scale overnight and rub salt inside and out, particularly around the backbone. In the morning, cut out fins and bone carefully, then roll and boil in vinegar and water, adding any spices desired.

SECRET OF THE TENCH

Tench are used a great deal on the Continent for soup. They are also considered a great delicacy both fried and baked as well as boiled. The flesh is very firm, but the skin is tender. The skin is considered by epicures to possess a savour comparable in its excellence to nothing else. The secret of how to prevent the breaking of

the delicate skin is known to very few cooks. Yet it is very simple. For boiling wrap the fish in a cloth and place in boiling water. Fry or bake in very hot fat, turning only once in the pan. Prepare the tench from eight to twelve hours before gutting and cooking, by laying it on a cushion of salt, cover with salt and put under fairly heavy pressure.

Smoked freshwater fish are acknowledged by gastronomical experts to make very good eating. Smoking them may be a novelty, but there are possibilities here for the creation of an industry. Smoked eels are, of course, one of the most expensive delicacies of the food market—and one of the most delicious, as well as being very nutritious. Smoking, if properly done, may bring carp and other freshwater fish into popular demand.

SMOKING FISH

For household purposes smoking fish is not difficult nor is there much cost attached. Hardwood sawdust, chips or fragments must be used for burning in a firebucket to provide the smoke; bracken is a substitute if hardwood is not easily procurable. To make the household smokehouse take a couple of wooden boxes, knock out the ends and place one on top of the other, cleating them together on the outside. With pieces of one-inch by two-inch, make one or more ledges opposite each other on the inside of the top box. Screw or nail these from the outside. Place the firebucket on the ground in the centre of this little smokehouse. Any old bucket, punched full of holes around the sides and bottom, will serve. Leave an opening in the lower box big enough to handle the firebucket and arrange a door or shutter so as to close it up when necessary.

Gut and clean the fish. Make a salt solution in a bucket, barrel or bath, strong enough to float a small potato. Place the fish in this and leave for from six to twenty-four hours. Then hang them to dry on thin rods or sticks passed through the gills. These sticks or thin rods should be cut to fit in the top box of the smokehouse with their ends resting on the ledges. When the fish are dry hang them in the box and put in the firebucket. It is smoke you want not heat, so the contents of the bucket must always smoulder and not flame.

Instead of immersion in a saline solution the fish can be dry salted.

Cover with salt and leave them for six to twenty-four hours. If for immediate use the shorter period is enough, but if they are to be kept for any length of time, the longer periods are necessary.

The same thing applies for the smoking. A few hours for immediate use, but for thorough smoking, several days. The fire need not be continuous night and day for the same batch of fish. About six hours daily for two or three days is enough. Should any fish drop from the sticks it is a sign that the fire is too strong and the fish are being cooked. Do not dampen the contents of the bucket, because the resulting steam will cook the fish rather than smoke them.

After being smoked, the fish should be packed in a clean box, lined and covered with clean paper, for use as required.

CHAPTER XXI

AQUARIUM

Aquarium keeping has become so popular and is practised so thoroughly the wide world over that little can be written nowadays which gives new information of any special value. Experience with an aquarium is apprenticeship to pond keeping and pond culture. A brief outline on aquarium keeping may encourage and help many hobby-seekers to take up aquiculture, beginning with its simplest form.

There are three divisions in the aquarium world—freshwater, marine, and tropical. The last requires warm water. Freshwater is the most favoured of these and is here described.

Aquariums can be purchased from aquatic dealers or constructed at home as described later in this chapter. The most popular form is rectangular in shape, made of glass in a metal framework. The glass should be plate glass. There are some made entirely of glass, impervious to leaks, but experience shows that the glass cracks more easily in changes of air temperature and is never quite clear. The cylindrical shape also cracks easily and, like the globe variety, has not the water surface area so desirable. Keeping fish in a globe or a very small aquarium is akin to cruelty and, sooner or later, leads to disaster. The best size is one to hold eight to ten gallons of water. The bottom should be slate. There is no better material for this purpose.

The aim of the aquarist must be to keep a proper balance between the animal and plant life in the aquarium.

SITING THE AQUARIUM

The aquarium should be so positioned that the light can be controlled. Artificial light from an electric bulb is allowable. Sunshine

is not wanted except for an hour or two on winter days, as it is liable to warm the water more than is helpful and stimulate the growth of algae and plants. A temperature of between fifty and sixty degrees Fahrenheit is the best and should not reach either seventy-five degrees, on the high side, nor forty-five degrees on the low. There is less oxygen in warm than in cold water and it is oxygen that is wanted.

Water plants in moderation are needed to help aeration. In daytime they give off oxygen. Plant life can be controlled by allowing it less light. A greenish tinge is spread rapidly on the glass by algae in strong light. This can be rubbed off, controlled by shading or allowed to remain to help aerate the water and be gradually eaten by snails. Any of the plants recommended for ponds and described in Chapter XV can be planted in the aquarium. But not too many—because the balance of animal and vegetable must be kept.

Fine gravel and sand, both well-washed, should be placed, two to three inches deep, in the bottom of the aquarium. The fish like to rub themselves against and through this, and here, also, the roots of plants will find their home.

DO NOT CHANGE THE WATER

The water in the aquarium should not be changed at all and only enough added occasionally to replace that lost by evaporation. The added water must be of the same temperature as that already in the aquarium. When water is siphoned from the bottom to clean the floor of the aquarium it should be saved, strained, and then poured back.

It is advisable to aerate the water occasionally. This can be done easily by dipping water gently from the aquarium into a bucket and then returning it by using a stirrup-pump with a spray nozzle. In this way the water in the aquarium is not agitated sufficiently to frighten the fish and yet it is well aerated. A pinch of salt put in the water now and again may ward off possible fungus and parasites. This can be varied by a use of Epsom salts. Earthworms can also be classed as a laxative medicinal food. For small goldfish they must be cut into small sections.

Before introducing fish into the aquarium, put in the plants. The roots must be pressed into the sand and a stone or two will keep

them in position. Give them a few days to anchor and establish themselves, also to allow the water time to reach a proper temperature. Pond snails and a couple of small tadpoles are necessary to act as scavengers. Now all is ready and the fish can be put in. One inch of fish, less tail, to one gallon of water is the golden rule. The can or other vessel in which the fish are brought to the aquarium should be dipped into the water and gently turned on its side so that the fish release themselves. Before doing this, however, test the temperature of both waters. The difference in the fish-can water must be adjusted very, very slowly; only a trickle of the aquarium water at a time.

FEEDING THE FISH

Feeding is discussed at length in Chapter XIII. Although much of this refers to trout, food for goldfish is also included. Chapter VIII also contains most of the necessary information about goldfish.

The best way to serve nourishment to the fish inhabiting an aquarium is by using a feeding tray. This can be made in a square shape, a foot or more in size. It should have a small rim to keep the food from washing off and be so constructed and weighted—allowing for the weight of the food—that the tray floats one and half inches below the surface of the water. After each meal the tray must be withdrawn and cleaned, ready for the next day. One meal a day suffices. Food which may fall to the bottom of the aquarium should be recovered by the use of a dip tube. This is a long, hollow glass tube about half an inch size, long enough to reach to the bottom of the aquarium. Close one end of the tube with the tip of a finger, place the other end over the debris to be removed, take away the finger pressure and air will bring the fragment up the tube. For larger fragments the forceps already mentioned will be useful. To clean the glass use a razor blade, inserted into a cleft stick and fastened with wire. A coin will also do the cleaning.

A dip net, about five inches wide, on a handle of fifteen inches, will be wanted to net the fish when occasion demands. The net should be of some soft material, such as muslin, window-curtain net or cheese-cloth.

Cleanliness, of the aquarium itself and all utensils appertaining to it, is of the utmost importance.

AQUARIUMS AS HATCHERIES

Aquariums are particularly useful on a goldfish farm. There they are used as hatcheries. Goldfish ova, if left in the spawning pond, would soon be eaten by predators. By removing the nests or the vegetation on which the ova has been deposited to an aquarium, incubation can take place without disturbance and the prospects of a good hatch. Aquariums can, in this way, also be used for perch and other ova. Aquariums used for hatching purposes differ in size according to the number of goldfish to be hatched and the size of the nests or clumps of vegetation on which the eggs are deposited. Garden pond owners who may wish to propagate goldfish would be advised to use this method. It is possible to make out of concrete a suitable aquarium for the purpose. It has a glass front—it is advisable to use plate glass for with ordinary window glass accidents may happen

CEMENT AQUARIUMS FOR HATCHING

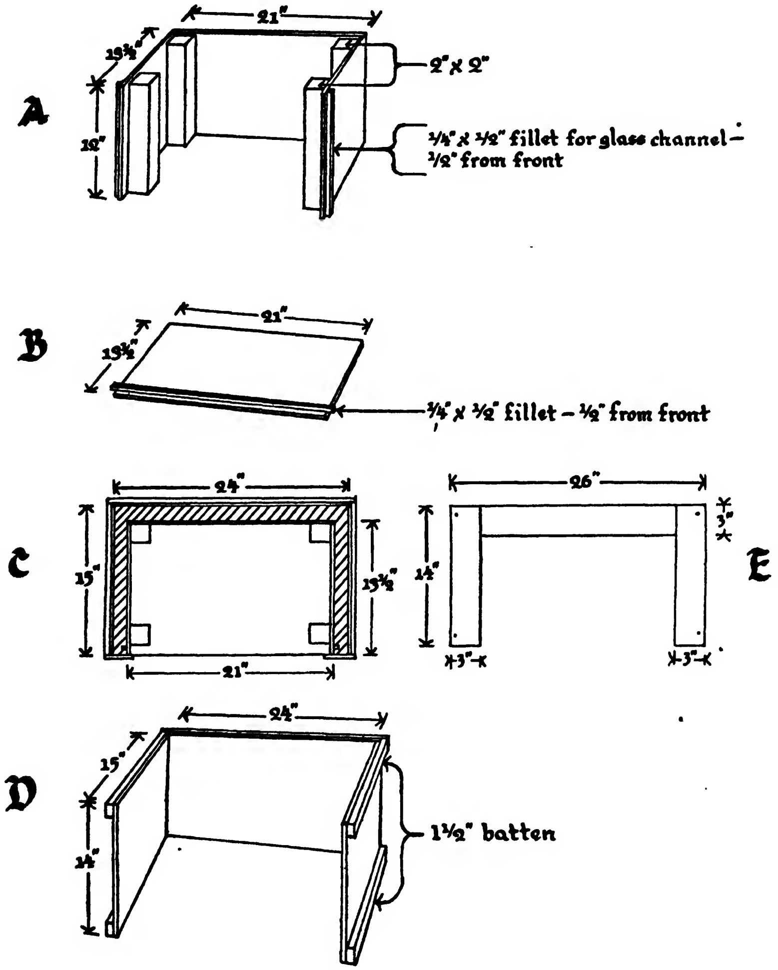
Because of the weight of concrete such an aquarium will have to be small to make it useful for its purpose. Cement aquariums are naturally heavy and difficult to handle. For incubation purposes the aquariums may have to be moved to the bank of a pond from positions in a shed or lean-to; or on or off supports. Such supports must be substantial for, in addition to the weight of the aquarium itself there is the weight of the water.

The size suggested for these aquariums is: two feet long, fifteen inches wide and fourteen inches deep. These are the outside measurements. The back and sides will be cement, one and a half inches thick; with a base two inches in thickness. Therefore, the inside measurements will be twenty-one inches long, thirteen and a half inches wide and twelve inches deep.

FRAMEWORK IS INVERTED

The construction of this aquarium is done upside down. If it is possible to procure half-inch T & G board this would be the easiest material to use. The ends could be screwed together, thus dispensing

with top battens which otherwise might be necessary. The mould, once made, can be used over and over again to make as many of these aquariums as required.



Build upon a flat surface by first laying out three sides with battens; these must be one and a half inches, or more. The one for the back measures two feet, those for the sides measure fifteen inches each. The joints at the back are squared. On the inside of this batten-framework of back and sides screw the outside shuttering of T & G board.

Next take four pieces of two-by-two inches, eleven and a half inches in height. Their function is to take the inside shuttering and support the baseboard during construction. On the cavity side of these four blocks screw the inside shuttering, all of it twelve inches in height—the extra half inch being taken by the baseboard—with the back measuring twenty-one inches in length and the sides thirteen and a half inches in length. Position this framework so as to allow a cavity of one and a half inches between the outside and inside shuttering. On top of the four uprights screw the half-inch base board. If one-inch board is used the uprights should be only eleven inches in height.

It is necessary to create a slot in the cement, in which the glass forming the front can be fitted. To do this fillets of wood are used. These fillets are wedge-shaped, tapering from half an inch to a quarter of an inch in width and half an inch deep. Each can be made in one piece, that is, twelve inches for each side and twenty-two inches for the front. It may be more convenient to cut them into smaller lengths for more accurate insertion. The fillets on the sides must be in line with the fillets on the front. The fillets are screwed in.

The mould is now complete. It is in two distinct parts, each of which is easy to handle for use in making additional aquariums.

Before cementing, screw on the framework which forms the temporary front.

SCREWS ONLY TO BE USED

It is advisable to use screws throughout. These should be dipped in oil or smeared with grease before screwing.

OIL OR WHITEWASH INSIDE SHUTTERING

All the shuttering on its insides and the baseboard must be oiled liberally or whitewashed. This is necessary to prevent the cement from sticking to the framework. Oil, too, the top edge of the inside shuttering.

OUTLET HOLE

In one corner of the baseboard drill a hole to take a one-and-a-half

inch rubber bung and insert in it a wooden plug, with more than two inches showing above the board so as to facilitate its removal after the cement has hardened.

Now the cementing can be done.

THE CEMENT MIXTURE

It is most important that the sand used should be exceedingly clean; it should be washed several times to ensure its purity. Only sharp sand should be used, never fine or dusty sand. In the past a water-tightening powder has been put into the mixture at the ratio of one pound to thirty-three parts cement. Nowadays it is simpler, perhaps, to use a waterproofing material on the cement when set. Should the powder be used, however, very great care must be taken in the mixing. This powder is very fine and light—finer than flour; the cement and sand should be thoroughly mixed first of all, then add the powder and mix again very gently. Next add water through a fine rose.

The usual cement mixture is one part cement and two parts of sand. It should be mixed very thoroughly both before and after adding water. It must be neither too heavy nor too runny—but just soft. Place about four inches of it into the mould and then spread some reinforcements.

REINFORCEMENTS

These consist of small pieces of metal such as old nails, bits of iron rod not over quarter inch in diameter; wire or poultry wire scraps.

Put in another four inches of the cement mixture and then some more reinforcements covering them with the final instalment of the cement mixture. Do not overdo the reinforcements.

Reinforcement should also be used on the base. A few quarter-inch iron rods, ten inches in length, should be laid on the first inch of cement and covered by the second inch.

Having filled the back and side shutterings until the twelve inches has been reached, proceed to place the mixture and reinforcements on the base board, spreading the mixture right back to the outside boards of the shuttering. See that the top of the cement on the base board is level.

THE FINISHING TOUCHES

It is advisable to allow seven days for the cement to harden thoroughly before taking off the framework, and adding the finishing touches.

First unscrew the temporary front framework. Then turn the whole construction over on the side where the glass will come. Lift off the two parts of the mould.

The aquarium is then ready to be turned on to its proper base and for the insertion of the glass, which must be twenty-one inches by ten inches. The glass must be quarter-inch plate glass.

The slots should be dressed with red lead and gold size. If the fillets have done their work properly and the glass has been cut exactly to size, the front should fit snugly. Once the glass is in the slots, take some of the special aquarium cement and press it along the edges of the glass.

Paint the whole of the inside of the cement aquarium with black varnish or other waterproofing material.

ANGLE-IRON CONSTRUCTION

Another type of aquarium can be made quickly and easily with the use of angle iron. But it will be more expensive.

Use one-and-a-half-inch angle iron cut to required size. Longer than three feet with eighteen inches in width and height is not recommended. Be sure that the measurement of each piece cut is exact. It is advisable to take these to a welder and have the frame welded at the corners. Twelve pieces will be required—four of three feet length, eight of eighteen inches for sides and uprights at the corners. The base should be of one-inch slate. Like the base of the cement aquarium a hole should be bored for an inch-and-a-half bung. The glass back and sides can be of ridged glass, known to the trade as Hartley Rolled. The front should be of quarter-inch plate glass. The glass rests on the iron, which is first treated with red lead and gold size. The slate base is also embedded in this mixture.

THE SPECIAL AQUARIUM CEMENT

A special cement for aquariums has been scientifically formulated.

The aim, naturally, was to find a cement that was non-toxic; that had strong, adhesive properties, that was water-resisting and would set well without turning into stone. This composition consists of a quart of silver sand or a very fine sand, a quart of plaster of Paris, one pound of litharge, two ounces of powdered resin. This is mixed to a putty with boiled linseed oil.

Another recipe consists of a putty made with boiled linseed oil and equal weights of whiting, litharge, and zinc white.

Litharge, used largely by paint manufacturers, is the semi-vitrified oxide of lead separated from silver in refining.

Before inserting the glass into position clean the edges with methylated spirit because of possible grease. Then paint the edges with gold size and allow it to dry for a couple of days. Then smear the special cement mixture on the angle iron and also on the edges of the glass; press the glass carefully into its place. Once in position scrape away surplus cement. When all the glass has been put into position brace with pieces of wood, from the inside, and allow several days for the cement to set before removing the braces. When this is done a little of the cement should be pressed into the corners and along the edges of the glass.

While this should make for watertightness, a further insurance is to press along the edges of the glass on the base and also up each corner a quarter-inch or one-eighth-inch glass rod, embedded in the aquarium cement.

In some aquariums the base extends an inch or an inch and a half beyond the frames on all sides. The top edge should be bevelled. Every ten inches the base and lower angle-iron are drilled to take a bolt. The under side of the holes in the base should be countersunk to allow for the nut. The holes in the angle iron should also be countersunk for depressing the bolt head. In the insertion of each bolt use some aquarium cement in the hole, scraping away all surplus. Always use slate as the base and not marble.

WOODEN HATCHING TANKS

The cement aquarium may be too big an affair for the garden pond owner, who, for his or her pleasure, wishes to breed from the goldfish or other fish in their pond. In this case a simpler method for

ensuring the hatching of the eggs is to use a wooden tank. In the opinion of many experts, a properly built and seasoned wooden tank is invaluable for breeding purposes. The best size is as follows: Length, four feet; width, two feet six inches; height, fifteen inches. With a choice of wood, use hardwood. The boards are one and a quarter inch and tongued and grooved. Before jointing and cramping them, the joints should be painted with white lead. The side and bottom boards should be rabbeted a quarter inch. At the ends the rabbeting should be one and a half inches from the edge. Insert one and three-quarter inch screws through the sides into the bottom and the ends and also through the bottom into the ends. Cleats, three inches wide, are screwed on the bottom of the ends and on the sides of the ends. A cleat should also be placed on the centre of the bottom. Through the top of the cleats on the ends pass a quarter-inch iron bolt fastened with nut and washer. Give the white lead time to dry and then paint the inside of the tank with black varnish or waterproofing paint.

There are very many homes where an aquarium is to be found, but they only come within the scope of fish culture if of the right size. They are then useful for hatching purposes. Otherwise Aquariums are in a world of their own, involving household pets or tropical fish.

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